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ACOUSTIC TECHNOLOGY COURSE

ENVIRONMENTAL ACOUSTICS TECHNOLOGY II

1975

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Ontario

Ministry of the Environment

The Honourable George A. Kerr, Q.C., Minister

Everett Biggs, Deputy Minister

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MINISTRY OF THE ENVIRONMENT

ENVIRONMENTAL ACOUSTICS

TECHNOLOGY II

1975

Training, Certification &
Safety Section
Technical Services Branch
40 St. Clair Avenue West
6th Floor
Toronto, Ontario

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Procedures and Policies expressed in this manual are those of the editor-in-chief and not necessarily those of the Ministry.

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General Radio Company

International Electrotechnical Commission

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GENERAL INFORMATION

Identifying a lecture period

Each topic will be assigned to a part of a course identified by a three letter number.

The first letter indicates which of the five courses the topic is covered under. The five courses are as follows:

Environmental Acoustics I

Environmental Acoustics II

Environmental Acoustics III

Environmental Acoustics IV

Environmental Acoustics V

The second letter signifies the work-day of the course. Each course lasts 5 days, thus numbers range between 1 and 5.

The third letter indicates the time during the day as coded below:

A: first morning session

B: second morning session

C: first afternoon session

D: second afternoon session

Example:

The lecture period II.3.D is in the Environmental Acoustics II course, on the 3rd day, in the second afternoon session.

Evening tutorial sessions arranged as required.

SUBJECT:

ENVIRONMENTAL ACOUSTICS II

TOPIC: II.1.A.& B. (Review)

OBJECTIVES:

Trainee will be able to:

1. Clarify and improve upon his understanding of the course material covered during Environmental Acoustics Technology-I, to be accomplished through revision of previous work.

SUBJECT:

ENVIRONMENTAL ACOUSTICS II

TOPIC: II.1.C. (Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Describe and give examples of impulsive sounds.
2. Describe how impulsive sounds are measured
3. Name and describe types of impulse sound level meters.

II.1.C.1. IMPULSIVE SOUNDS:

Typically, impulsive sounds are those sounds which have durations of less than 1 second. A further classification can be made between single impulsive sounds, for example a pistol shot, door slamming and a tyre bursting and rapidly-repeated impulsive sounds, such as machine gun fire, riveting and hammering. For the first class of impulsive noises not only must annoyance be considered in their control but also startle or fear due to their sudden occurence without warning. Repeated impulsive sounds are more causes of simple annoyance once the noise has started. Impulsive noises of high level can also be the cause of hearing loss. To measure such sounds, particularly single impulsive sounds, a special sound level meter known as an "impulse sound level meter" is required.

II.1.C.2. THE MEASUREMENT OF IMPULSIVE SOUNDS:

The measurement of impulsive sounds is made difficult by their very short duration and the high instantaneous sound pressure levels attained during their existence. A second problem is that very few closely defined procedures exist for their measurement, particularly from the viewpoint of annoyance.

Can the ordinary sound level meter be used to assess impulsive noises? In some cases it can. Rapidly-repeated impulses are often known as quasi-steady. This is because a sound level meter set to "Fast" or "Slow" response would, after several impulses, indicate a practically steady level. Rivetting and machine-gun fire are examples of this type of situation. The simple sound level meter in this instance can give an indication of the high levels reached by impulsive noises because the needle just does not have time to fall very far before the next impulse comes along. In this situation however, the maximum meter deflection should be taken, not the mean value. If the sound level meter needle is making large excursions across the scale on "Fast" or "Slow" setting (typically greater than 3dB) then these settings are not suitable for the measurement, and an impulse sound level meter will be required.

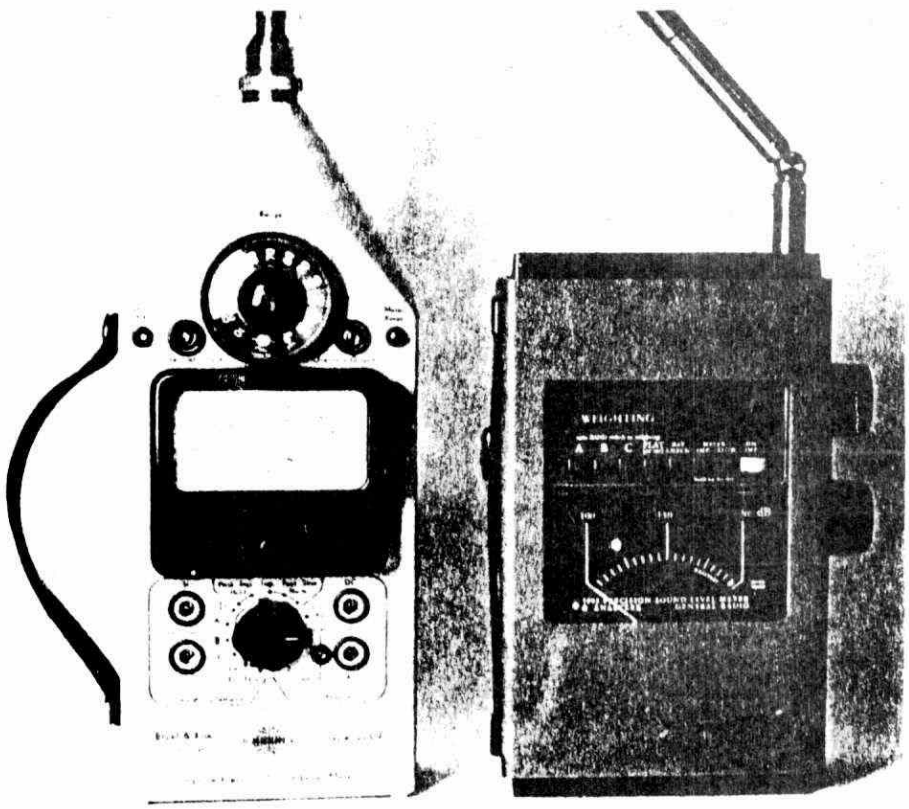
When a sound level meter is set to "Slow" or "Fast", the instrument effectively takes what is known as a Root Mean Square (RMS) value

with a certain meter response defined by the "Slow" or "Fast" setting. The needle will follow an impulsive sound better with "Fast" than "Slow", but still will not be able to keep pace with the rapidly rising and falling sound pressure. If the meter response was made even faster than "Fast" then eventually the meter needle could keep up with the impulse and give a correct maximum RMS value.

Such a sound level meter response has been standardized in the International Electrotechnical Commission publication IEC 179A (which is a supplement to IEC 179, Precision Sound Level Meters) entitled "Additional Characteristics for the Measurement of Impulsive Sounds". (See Appendix I at the end of this section.)

The characteristics specified for an impulse sound level meter are twofold. First the meter must have a response time of 35 m.sec to the initial rising portion of the impulse (compared with 100 m sec for Fast and 500 m sec for Slow) enabling it to keep up with some impulsive sounds. The second characteristic of the impulse sound level meter was originally meant to simulate the tendency of the human brain to slowly "forget" impulsive noises. For this reason it was specified that after the impulse, the needle should fall slowly with a response time of 3 sec. This also makes the maximum reading a little easier to read.

Although the "Impulse" meter response just described is faster than Fast there are still some impulses that have such a rapid rise in sound pressure that the meter still cannot keep up with them. For this reason some sound level meters are provided with an even faster response known as "Peak". Even though it is not necessary under the IEC 179A standard to have such a response (Peak is mentioned however) it is very useful for measuring impulsive sounds and its use is often specified for hearing loss prevention and blasting noise assessment. The peak feature is not really an RMS measurement of the actual instantaneous maximum sound pressure level achieved by an impulsive noise. It would clearly be very difficult to read a meter needle following impulsive sounds so rapidly. For this reason, a "Hold" circuit is sometimes provided which holds the peak value so that it can be read easily.



(a) (b)

Figure II.1.C.1: (a) B & K Type 2209 Impulse Precision Sound Level Meter.

(b) G.R. Type 1933 Precision Sound Level Meter.

II.1.C.3. IMPULSE SOUND LEVEL METERS:

The leading manufacturers of sound measurement equipment produce impulse sound level meters. These are Bruel and Kjaer (B & K) and General Radio (GR). The B & K Type 2209 Impulse Sound Level Meter is shown in Fig. II.1.C.1.(a). In addition to Fast and Slow, it provides meter responses of Impulse, Impulse Hold and Peak Hold. It also provides overload indication (as specified in IEC 179A), is battery operated, and very similar in appearance to the Type 2203 Precision Sound Level Meter produced by the same company. The G.R. Type 1933 Precision Sound Level Meter and Analyzer is also shown in Fig. II.1.C.1 (b). It also provides Fast, Slow and Impulse modes. Later models have a small switch on the side to give Peak (described as "PK(Impact)" on the meter). This meter is again battery operated and provides overload indication.

Oscilloscope Method of Measuring Impulsive Sounds:

A useful instrument for measuring the peak level of an impulsive sound is a storage cathode ray oscilloscope. The AC output is taken from any precision sound level meter and passed to the input of the storage oscilloscope. Calibration of the oscilloscope is performed most easily by using a sound level calibrator on the sound level meter microphone. Calculate the RMS pressure due to the sound level produced by the calibrator (using the dB definition in reverse) and multiply by 1.41 (the correction between RMS and peak for a sine wave is $\sqrt{2}$). The resulting pressure should then be compared with the peak deflection of the calibration signal wave on the oscilloscope screen. For a particular sound level meter attenuation and oscilloscope Volts/div sensitivity setting, the conversion from peak trace deflection to pressure can be made.

The pressure should then be converted to a dB level using the following formula

$$dB\ (Peak) = 10 \log \left(\frac{P_{PEAK}}{P_{REF}} \right)^2$$

where P_{REF} is the reference pressure of 20 μPa.

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APPENDIX I OF II.1.C

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

(affiliée à l'Organisation Internationale de Normalisation — ISO)

RECOMMANDATION DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

(affiliated to the International Organization for Standardization — ISO)

IEC RECOMMENDATION

Publication 179A
1973

Premier complément à la Publication 179 (1973)
Sonomètres de précision
Caractéristiques supplémentaires pour la mesure des bruits impulsifs

First supplement to Publication 179 (1973)
Precision sound level meters
Additional characteristics for the measurement of impulsive sounds

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRST SUPPLEMENT TO PUBLICATION 179 (1973)

PRECISION SOUND LEVEL METERS

Additional characteristics for the measurement of impulsive sounds

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendations and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This recommendation has been prepared by Sub-Committee 29C, Measuring Devices, of IEC Technical Committee No. 29, Electro-acoustics.

It forms the first supplement to the second edition, issued in 1973, of IEC Publication 179, Precision Sound Level Meters. Since the issue in 1965 of the first edition of IEC Publication 179, sound level meters for the measurement of impulsive noises have also been studied and built by manufacturers and are now commercially available.

In view of the fact that the second edition of Publication 179 did not include sound level meters for the measurement of impulsive noises, it was considered necessary for Sub-Committee 29C to prepare a draft supplement to Publication 179 (second edition) covering such equipment.

As a result of the meeting held in London in April 1971, the final draft of this supplement, document 29C(Central Office)16, was submitted to the National Committees for approval under the Six Months' Rule in November 1971.

The following countries voted explicitly in favour of publication:

Australia	Netherlands
Belgium	Norway
Canada	Romania
Denmark	Sweden
Egypt	Switzerland
Finland	Turkey
France	Union of Soviet Socialist Republics
Germany	United States of America
Israel	
Japan	

Important note

Concurrently with the preparation of this IEC recommendation, further research work on the loudness of impulsive sounds has been carried out by ISO Technical Committee 43 (Sub-Committee 1, Study Group B). Although this work is not yet complete, interim results have been reported which, if adopted as a basis for an impulse sound level meter, might result in changes to the present recommendation. Since this recommendation conforms to existing practice in the construction of impulse sound level meters, however, it is considered prudent to issue it in its present form and to consider the advisability of an amendment at a later date, when the work of ISO is completed.

FIRST SUPPLEMENT TO PUBLICATION 179 (1973)

PRECISION SOUND LEVEL METERS

Additional characteristics for the measurement of impulsive sounds

1. **Scope**

1.1 This recommendation specifies the characteristics of an apparatus for measuring sounds including sounds of short duration, single impulses and sequences of impulses (pulses).

1.2 The apparatus specified in this recommendation complies with the requirements for the precision sound level meter described in IEC Publication 179 and, in addition, is suitable for measuring impulsive sounds when the purpose is to obtain a value representative of the approximate loudness.

1.3 An apparatus which meets the specifications of this recommendation may be called an impulse sound level meter. The instrument may be marked with the word "Impulse" in addition to "Precision Sound Level Meter".

2. **Object**

2.1 The precision sound level meter described in IEC Publication 179 is not suitable for measuring sounds of short duration or impulsive sounds. Such sounds are frequently encountered in practice. For this reason, it is appropriate to state the following requirements which, in addition to those given in Publication 179, are to be fulfilled by a precision sound level meter for the measurement of impulsive sounds.

2.2 These additional requirements concern particularly the dynamic properties of the indicating device and the overload capacity of the amplifier stages and square law rectifier. These characteristics are based on subjective investigations of the loudness of impulsive sounds. The response of the ear to such sounds is simulated approximately by first squaring the voltage which corresponds to the sound pressure, then averaging the squared voltage with an RC combination that has equal time constants for charge and discharge, taking the square root of the voltage across the capacitor of the RC combination and finally storing the voltage in an additional capacitor circuit having a controlled leakage path.

2.3 The spread of the results of subjective investigations of the loudness of impulsive sounds is considerably greater than for continuous sounds. However, it is desirable to standardize the performance requirements for an apparatus by which impulsive sounds can be measured under closely defined conditions so that results obtained by users of such apparatus can be compared with one another and with subjective assessments. The standardization of such an apparatus does not imply that the relationship between the loudness of impulsive sounds and the physical characteristics of such sounds is precisely known. The standardization of an impulse sound level meter is intended to encourage further research in this important area. The tolerances given in tabular form in this publication have been set to provide reproducible characteristics and do not correspond to the spread of the subjective investigations.

3. **Definitions**

3.1 For the purpose of this recommendation, an impulsive sound is defined either as a single pressure pulse or a single burst (multiple pressure pulses) having a duration in the range between 1 ms and 1 s.

3.2 For the purpose of this recommendation, a sequence of impulses is defined as having a time interval between successive impulses in the range between 10 ms and 1 s.

3.3 Impulse sound pressure level is defined by:

$$L_{pI} = 20 \log_{10} \frac{p_I}{p_0} \text{ dB}$$

where:

p_I is the unweighted sound pressure measured with an apparatus having the characteristics specified in this recommendation, and

p_0 is the reference sound pressure: 20 μPa ($= 2 \times 10^{-5}$ N/m^2)

3.4 Impulse weighted sound level A is defined by:

$$L_{AI} = 20 \log_{10} \frac{p_{AI}}{p_0} \text{ dB}$$

where:

p_{AI} is the A-weighted sound pressure measured with an apparatus having the characteristics specified in this recommendation.

Impulse sound levels are expressed in decibels (dB); the weighting used should always be stated as well as the dynamic characteristic "impulse"; e.g. impulse sound level A = 73 dB; L_{AI} = 73 dB; 73 dB (AI).

Note. – At the present time, the use of B-weighted impulse sound level L_{BI} and C-weighted impulse sound level L_{CI} is not recommended.

3.5 For the purpose of this recommendation, the crest factor of a sound pressure or voltage signal is defined as the ratio of the peak value to the r.m.s. value of the signal where the peak and r.m.s. values are measured with reference to the arithmetic mean value of the signal. The relation between crest factor and pulse duty factor for sequences of rectangular pulses and for tone bursts is given in Appendix B.

4. **Characteristics**

4.1 *General characteristics*

4.1.1 The apparatus shall comply with the requirements for the precision sound level meter described in IEC Publication 179.

4.1.2 The dynamic characteristic "slow" shall be provided.

4.1.3 The apparatus shall provide a dynamic characteristic designated "impulse" which meets the requirements of this publication.

4.2 *Detection of overload*

Overload detectors shall be provided to indicate clearly when any circuit is overloaded.

4.2.1 The following test shall be carried out. Set the instrument to *A*-weighting and replace the microphone with an electrical impedance equal to that of the microphone. Feed a sinusoidal signal of frequency 1 000 Hz in series with this impedance and adjust the amplitude to give a reading on the instrument of 5 dB below full-scale. Reduce the frequency of the input signal in steps to 20 Hz while simultaneously increasing the amplitude by an amount corresponding to the *A*-weighting characteristic. Note the reading at each frequency. If at any frequency the reading deviates from the initial value by an amount exceeding the tolerance for that frequency given in the Appendix to IEC Publication 179, then an overload indication shall occur.

The test shall be performed with the most critical setting of the range switch.

4.2.2 Additionally, when the sound level meter includes means for insertion of an external filter or weighting network, an overload indication shall occur when the total harmonic distortion* at the input of the filter or weighting network is greater than 5% or when, with rectangular pulses of either polarity and crest factor greater than 5 (pulse duty factor $T/t_1 > 26$), the reading with the "slow" characteristic deviates by more than 1.5 dB from that of a continuous sine wave corresponding to any reading in the range between 1.5 dB below and 10 dB below full-scale. Continuous sine wave and the pulse test signal shall have identical r.m.s. values and the measurements shall be performed according to the requirements given in Sub-clause 4.3.1.

The overload detectors shall be equally responsive to single rectangular impulses of either polarity and duration in the range 200 µs to 10 ms.

Note. — The operating instructions supplied with the apparatus shall state that in case of overload the range switch shall be set to the next higher measuring range and that the measurement shall then be repeated. If the overloading continues, this fact is to be stated together with the measured value, because it is assumed that without overload a higher value might be obtained.

4.3 *Detector characteristics*

4.3.1 The error resulting from using the apparatus in its "slow" position to measure the r.m.s. value of a sequence of rectangular pulses is tested using a sine wave signal as reference. It is recommended that the sine wave should have a frequency of 2 000 Hz. The pulses shall have a duration of 200 µs, rise times not greater than 10 µs and the r.m.s. value of the sequence of pulses shall be identical to that of the sine wave signal. The test shall be conducted using pulses of both polarities. The r.m.s. reference values are measured with a device that introduces weighting to the signal identical to that in the apparatus.

The test signal is fed to the electrical input of the apparatus. For signals with crest factors up to 3 (pulse duty factor up to 10), the tolerance is ± 0.5 dB; with crest factors between 3 and 5 (pulse duty factors between 10 and 26), the tolerance is ± 1 dB. The test shall be performed 1 dB below full-scale reading and again 15 dB below full-scale reading. A test with rectangular pulses having

* *Note.* — Total harmonic distortion is given by: $100 \sqrt{\dfrac{x_{2f}^2 + x_{3f}^2 + \ldots + x_{nf}^2}{x_1^2 + x_{2f}^2 + \ldots + x_{nf}^2}}$

where x_1 is the amplitude of the fundamental and $x_{2f}, x_{3f}, \ldots x_{nf}$ that of the respective harmonics.

crest factors up to 10 (pulse duty factor 101) shall also be performed. Signals with crest factors up to 10 (pulse duty factor 101) shall be measurable with a tolerance of ± 1.5 dB over an indicating scale range of at least 15 dB which shall be specified.

The conditions stated above shall also be fulfilled when tone bursts (frequency 2000 Hz, repetition frequency 40 Hz) with crest factors up to 3 (pulse duty factor 4.5), up to 5 (pulse duty factor 12.5) and up to 10 (pulse duty factor 50) are applied as test signals.

4.4 *Characteristics of the indicating instrument*

4.4.1 With the characteristic marked "impulse", the reading of the impulse sound level meter shall not differ from that with the "slow" characteristic by more than 0.1 dB for a sustained sinusoidal signal in the frequency range 315 Hz to 12 500 Hz or by more than 0.7 dB for a sinusoidal signal in the range from 31.5 Hz to 315 Hz. For impulsive sounds and sounds of short duration, the indication of the instrument with the "impulse" characteristic will generally be higher (see Subclause 4.4.3).

4.4.2 The voltages produced at the output of the rectifier circuit (including the RC combination) shall be stored in such a way that the voltages can be read on the indicating instrument. The rise time of the storage device shall be small compared with the time constant of the averaging RC combination, while the decay time of the storage device shall be 3 ± 0.5 s.

4.4.3 The impulse sound level meter in the "impulse" position shall possess the following dynamic characteristics of indication:

4.4.3.1 For a single sinusoidal burst with a frequency of 2000 Hz, a duration t_i and a constant amplitude which produces a full-scale deflection of the indicating instrument for a continuous signal, the reading relative to the reading of the continuous signal shall be as stated in Table I.

TABLE I

Reading for a single burst

Duration t_i ms	Maximum reading with respect to full-scale deflection dB	Tolerance dB
Continuous	0	0
50	− 1.2	± 1
20	− 3.6	± 1.5
10	− 6.0	± 2
5	− 8.8	± 2
2	−12.6	± 2

4.4.3.2 For a sinusoidal signal with a frequency of 2000 Hz, a duration of 5 ms, a repetition frequency f_p and where a full-scale deflection is produced when the signal is continuous, the reading relative to the reading of the continuous signal shall be as stated in Table II.

TABLE II

Reading for sequences of bursts

Repetition frequency f_p Hz	Maximum reading with respect to full-scale deflection dB	Tolerance dB
Continuous	0	
100	−2.7	$\begin{matrix}+1\\-0.5\end{matrix}$
50	−5.1	$\begin{matrix}+1.5\\-1\end{matrix}$
20	−7.6	± 2
10	−8.5	± 2
5	−8.7	± 2
2	−8.8	± 2

Note. — The values in Tables I and II are calculated with a time constant of 35 ms for the charge and discharge of the averaging RC combination connected to the rectifier circuit.

4.4.3.3 The test described in Sub-clause 4.4.3.2 shall be repeated for the condition where the continuous signal produces a deflection 4 dB less than full-scale reading.

4.5 *Optional characteristics*

4.5.1 If the impulse sound level meter is also equipped for measuring peak values, the rise time of the peak detector shall be such that a single pulse of 200 µs duration produces a meter indication within 2 dB of the indication produced by a pulse having a duration of 10 ms and equal peak amplitude. The amplitude of the 10 ms reference pulse shall be such as to produce a meter deflection 1 dB below full-scale. It is recommended that the switch be marked "peak".

APPENDIX A

BLOCK DIAGRAM OF THE IMPULSE SOUND LEVEL METER

A block diagram of the impulse sound level meter is given in Figure 1.

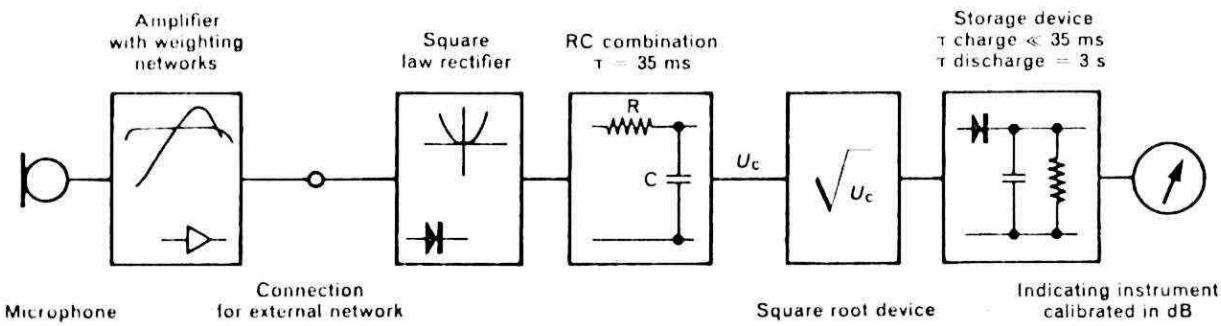


FIGURE 1

The values given in Table I for a single burst are obtained from the following expression:

$$\Delta L = 10 \log_{10} \{1 - \exp(-t_1/\tau)\}$$

The values given in Table II for sequences of bursts are obtained from the expression:

$$\Delta L = 10 \log_{10} \left\{ \frac{1 - \exp(-t_1/\tau)}{1 - \exp(-T/\tau)} \right\}$$

In the above expressions:

t_1 is the burst duration

$\tau = 35$ ms is the time constant of the averaging RC combination following the rectifier

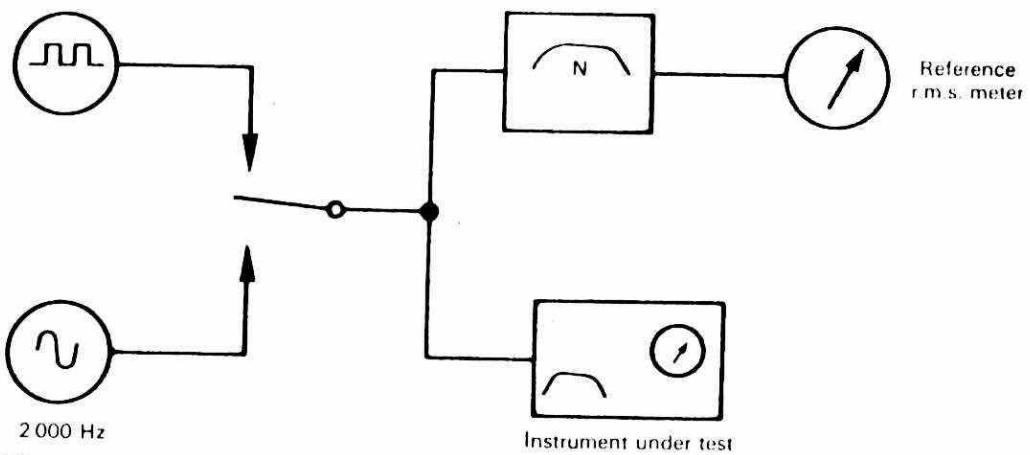
$T = \frac{1}{f_p}$, f_p being the repetition frequency of the bursts.

APPENDIX B

TESTS OF THE OVERLOAD AND DETECTION CHARACTERISTICS

Tests of the overload and detection characteristics of the instrument are carried out with rectangular pulse sequences and with tone bursts.

B1. Rectangular pulse test



N is the network that introduces a frequency weighting identical to that in the instrument under test.

FIGURE 2

Apply the 2000 Hz sinusoidal signal to the instrument under test and simultaneously to a reference system having a true r.m.s. response and frequency weighting identical to that in the instrument under test. Note the indication of the reference meter.

Apply the rectangular pulse sequence and adjust its amplitude to give an indication of the reference r.m.s. meter identical to that for the sine wave signal. The instrument under test shall give an indication within the tolerances specified in this recommendation (see Sub-clause 4.3.1).

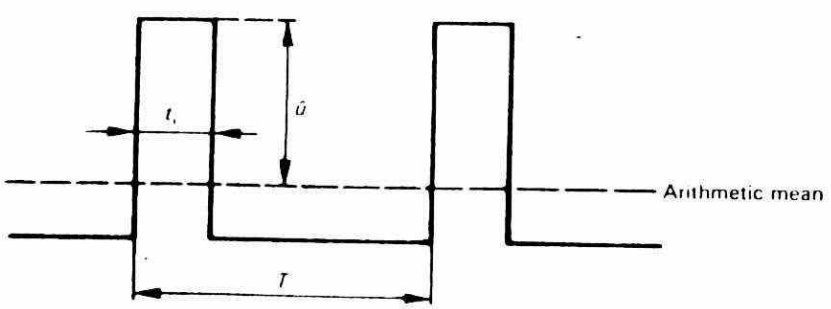


FIGURE 3

The relation between crest factor $\frac{\hat{u}}{u}$ and pulse duty factor $\frac{T}{t_1}$ is given by:

$$\frac{\hat{u}}{u} \quad \sqrt{\frac{T}{t_1}} \quad 1$$

where:

$\hat{u}$ is the peak value of the signal measured with reference to the arithmetic mean

u is the r.m.s. value of the signal measured with reference to the arithmetic mean

T is the fundamental period of the signal

t_1 is the time during which the signal is at its peak value $\hat{u}$.

B2. Tone burst test

The rectangular pulse generator of Figure 2, page 19, is replaced by a tone burst generator and the procedure described above is repeated using appropriate crest factor. The relation between crest factor and pulse duty factor in this case is given by:

$$\frac{\hat{u}}{u} = \sqrt{2\frac{T}{t_1}}$$

where:
$\hat{u}$, u and T are as defined above, and

t_1 is the time during which the signal has a non-zero value.

SUBJECT:

ENVIRONMENTAL ACOUSTICS II:

TOPIC: II.1.D. (Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Explain the concept of converting a time-varying noise level to a continuous energy equivalent level;
2. Define L_{eq};
3. Outline trade-off relationship of time vs. sound level;
4. Transform the L_{eq} values measured during one time interval to different time durations.

II.1.D.1 CONVERTING A TIME-VARYING NOISE TO AN ENERGY EQUIVALENT CONTINUOUS LEVEL:

Many community noise sources do not produce noise of a steady nature. Noise sources such as traffic, construction sites and radios produce noise levels which are time-varying, often between very wide limits. Unfortunately, a sound level meter is not sufficient to measure such unsteady noises. It is advised that if a sound-level meter needle is fluctuating through more than about 3 dBA, taking a simple eye average of the fluctuations will be inaccurate and should not be attempted. Clearly, if a noise is varying by more than this amount, a regular sound-level meter will not be suitable for assessing the noise source.

In order to assess time-varying noises, the unsteady sound level (still measured in dBA) must be averaged in some way to provide an equivalent continuous level which will have the same annoyance value as the original sound. Exactly how this averaging is to be performed can only be decided by research into the response of human beings to varying noises. Considerable research has been done to determine how this averaging should be performed.

Simple averaging of the time-varying pressure of the sound is not a good method of assessing the annoyance of unsteady noises. This method tends to underestimate the annoyance value. It is clear from this statement that an averaging method is required which puts more emphasis on the higher levels than simple pressure-averaging. It has been found that if the energy (which is proportional to the square of the pressure) of a time-varying sound is averaged, then the resulting energy-equivalent continuous level (L_{eq}) has good correlation with the annoyance of that sound.

For the purpose of environmental noise controls in Ontario, the community-noise descriptor, L_{eq}, has been selected. The adoption of L_{eq} does not necessarily preclude the use of other descriptors.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.2.A.& B.(Workshop)

OBJECTIVES:

Trainee will be able to:

1. Calibrate, check and use impulse sound level meters (Type B.&K. 2209 and G.R. 1933);
2. Complete the measurement sheets correctly by the end of the workshop period, and be able to answer related questions.

II.2.A.& B.1 CALIBRATION, CHECKING AND USE OF IMPULSE SOUND LEVEL METER:

In this workshop two types of impulse sound level meters will be used to measure impulsive sounds. Detailed instruction for calibration and use of these sound level meters will be given individually in the following sub-sections. The actual measurements required for the workshop will then be given together with data sheets for completion. It is important that the instructions for use are followed explicitly when performing the measurement portion of the workshop.

B & K 2209, Impulse Precision Sound Level Meter:

(a) Assemble the B & K 2209, using a ½ inch microphone, gooseneck and tripod. Check that attenuator scale '2A' is in use and that the meter scale is turned to "PRECISION SOUND LEVEL METER".

(b) Turn the METER SWITCH to "Batt (Rec)". If the meter needle does not deflect to the "Batt" portion of the scale, replace the batteries.

(c) Calibrate the instrument using a B & K Type 4230 sound level calibrator. Set the following:

WEIGHTING NETWORK	"Lin"
METER SWITCH	"Fast"
OUTPUT ATTENUATOR (clear)	"fully clockwise"
INPUT ATTENUATOR (black)	"90 dB"

Place the Sound Level Calibrator (with appropriate adaptor) onto the microphone and press the start button. Using a small screwdriver adjust the "GAIN ADJ" potentimeter to give a deflection of 93.8 dB. Remove the Calibrator from the microphone.

(d) To take a sound level measurement, set the following:

WEIGHTING NETWORK	"Lin"
METER SWITCH	"as required"
OUTPUT ATTENUATOR (clear)	"fully clockwise"
INPUT ATTENUATOR (black)	"160"

Turn the INPUT ATTENUATOR (black) progressively clockwise (↷) until a meter deflection is obtained (when an impulse occurs), in the upper 10 dB of the meter scale. If the OVERLOAD INPUT light flashes then the INPUT ATTENUATOR (black) must be turned anti-clockwise (↶) until the light just stops flashing.

(e) Select the required weighting network, either "Lin" or "A".

(f) If necessary turn the OUTPUT ATTENUATOR (clear) anti-clockwise until a deflection is within the upper 10 dB of the meter scale. If the "OVERLOAD OUTPUT" flashes then switch the OUTPUT ATTENUATOR clockwise until the light just stops flashing. If the meter needle has too small a deflection to read then the noise being measured is outside the instruments capability.

(g) Read the sound level from the meter needle and attenuators. Note the sound level, along with the weighting network used and the "METER SWITCH" setting. Write the value down.

(h) To turn the sound level meter off, switch the "METER SWITCH" to "Off".

G.R. Type 1933 Precision Sound Level Meter:

(a) Determine the serial number (printed on the threaded end) of the ½ inch microphone. Lift up the top lid of the instrument and determine from the serial number whether the ½ inch microphone is type A or B. Set the SOURCE knob to A or B. Read the "MAX MIKE dB" off the table for the ½ inch microphone. Set the "MAX MIKE dB" control on the side of the instrument to this value. Again underneath the lid set the "MANUAL OVERRIDE" to the same "MAX MIKE dB" value.

(b) Assemble the G.R. 1933 using the ½ inch microphone and tripod and extend the microphone mast.

(c) Turn the instrument on by pressing the "ON/OFF" button. Press the "BAT CHECK" button and if the meter needle does not deflect to the "Battery" portion of the scale, change the batteries.

(d) Set the "OCTAVE BAND/WEIGHTING INDICATOR" to Weighting position, press the "FLAT" button, release both the "IMP" and "SLOW" buttons to select "FAST" and set the "dB LEVEL" switch to indicate 120 dB full scale on the meter. Set the "IMPULSE/PK(IMPACT)" switch on the side of the sound level meter to "Impulse".

(e) Take the G.R. 1562-A sound level calibrator and turn the nameplate momentarily clockwise to "Bat Check" (if the small lamp does not light, replace the battery) and then anti-clockwise to 1000 Hz. Place the calibrator on the microphone

(using a suitable adaptor) and using a small screwdriver adjust the recessed "CAL" control to give a meter needle deflection of 114 dB.

(f) To take a sound level measurement select "A" or "Flat" as required. Select "Slow", "Fast" or "Impulse" using the "IMP" and "SLOW" buttons. Select "Peak" by pressing "Imp" and switching the "IMPULSE/PK (IMPACT)" switch to "Pk (Impact)". Turn the "dB LEVEL" switch to give the highest dB range possible and progressively decrease the dB range (when an impulse occurs) to get an "on scale" reading. If the "OVERLOAD" lamp lights then increase the dB LEVEL switch until it just goes out. If there is no meter deflection then the sound being measured is beyond the instrument's capability.

(g) Read the sound level from the meter. Note the sound level along with the weighting network and effective meter response.

(h) To turn the sound level meter off, release the "ON/OFF" button.

II.2.A.& B.2 MEASUREMENT SHEETS ON IMPULSE NOISE ANALYSIS:

Complete the following two data sheets (Figures II.2.A.& B.1 and 2) using the B & K 2209 and the G.R. 1933 to measure impulsive noises of three types - single impulses, slowly repeated impulses and rapidly repeated impulses. Refer constantly to the previous directions for operating these two instruments. If necessary refer further to the instruction manuals for the instruments. Consider and carefully answer the questions on data sheet 3. (Figure II.2.A.& B.3).

Note: Please note that completed data sheets must be handed in at the end of this workshop period.

II.2.A.& B. (Workshop)

Data Sheet 1 Trainee's Name:

B & K Type 2209 Impulse Precision Sound Level Meter

Type of Noise						
	Single Impulse		Slowly Repeated Impulse		Rapidly Repeated Impulse	
Meter Response	Linear	A-weighted	Linear	A-weighted	Linear	A-weighted
Slow						
Fast						
Imp						
Imp Hold						
Peak Hold						

NB: Note maximum readings in each case.

Figure II.2.A.& B.1

II.2.A.& B. (Workshop)

Data Sheet 2 Trainees Name:

G.R. Type 1933 Precision Sound Level Meter and Analyzer

Type of Noise						
	Single Impulse		Slowly Repeated Impulse		Rapidly Repeated Impulse	
Meter Response	Linear	A-weighted	Linear	A-weighted	Linear	A-weighted
Slow						
Fast						
Imp						
Imp Hold						
Peak Hold						

NB: Note maximum readings in each case.

Figure II.2.A.& B.2

Figure II.2.A.& B.3

Data Sheet 3

Trainee's Name:

Examine Data Sheets 1 & 2 for this workshop, study and answer the following questions:

1. Are there any significant differences between Linear and A-weighted measurements of impulsive noises? If so, what are typical differences and why do they occur?

Answer:

2. Are "fast" or "slow" ever a suitable meter response for impulsive sounds? If so, which is the most suitable and for what sounds?

Answer:

3. On the 2209 was there any difference between "Imp" and "Imp. Hold", If so, why?

Answer:

4. Were there any differences between Imp. and Peak (Pk) measurements? Would you expect differences, if so, why?

Answer:

5. Were there any differences between Peak Hold on the 2209 and PK Impact on the 1933? If so, why?

Answer:

SUBJECT:
ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.2.C.& D.(Workshop)

OBJECTIVES:

Trainee will be able to:

1. List purposes behind employing a tape recorder in noise analysis;
2. Outline the principle of magnetic recording;
3. Describe functioning of a typical recorder (UHER 4200 portable model);
4. Indicate how tape speed affects the frequency response of a tape recorder;
5. Operate UHER 4200 tape recorder;
6. Use a tape recorder to record noise signals in the field and subsequent playback in the laboratory;
7. Perform frequency analysis of the recorded noise signal and compare it with corresponding site measurements. Complete appropriate data sheet.

II.2.C.& D.1 TAPE RECORDER IN NOISE ANALYSIS:

In many cases of noise measurement it is convenient and sometimes necessary to be able to record and store the original noise signal for later reproduction and analysis in the laboratory.

A tape recorder is a very useful tool in the processing of noise signals. **Typical applications of a tape recorder** in acoustic signal analysis are the following:

- **Measurement and evaluation of impulsive noise, transient or intermittent noise,** and various types of semi-stationary noise.
- **Tranformation of low-frequency signals up** into the range of ordinary frequency analysers, making very low-frequency analysis possible with relatively inexpensive instrumentation and also with considerable saving in time. This is achieved by speeding up the tape speed during play-back.
- **Transformation of high-frequency signals down** into the range of ordinary pen recorders, making it possible to obtain a realistic trace of the wave form of the signal. This is done by slowing down the tape speed during play-back.
- **Continuous repetition** of transient signals for frequency analysis.
- **Automatic operation** in association with a time clock or a sound level trigger, thereby making it unnecessary to have a person continuously attending and reading a sound level meter. (A sound level trigger is a circuit which switches on the recorder when the sound level reaches a pre-set value.)
- A tape recorder is easily transportable, making it possible to perform a complex analysis of the sound in the laboratory when the analysis equipment itself cannot easily be taken to the original site of the noise event.

II.2.C.& D.2 PRINCIPLE OF MAGNETIC RECORDING:

In modern magnetic recorders, the basic recording medium is magnetic tape, which consists of a substrate of some plastic material, about 20 μ thick on which is deposited a magnetic layer, about 10 μ thick, of iron oxide powder in a binding material.

The tape is moved at a constant speed past a magnetic head assembly. In professional machines this consists of three heads, erase, record and reproduce, arranged in that order.

The record head receives an electric current whose instantaneous value corresponds to the signal being recorded. The electric current sets-up a magnetic field in the magnetic material on which a coil is wound and the magnetic field fringes out through a tiny air gap in the magnetic structure towards the tape at the point where the tape contacts the head. The magnetic field in the gap magnetizes the magnetic material of the tape; and the tape retains that magnetic characteristic as it leaves the record head.

The recorded signal is recovered from the tape by a reproduce head which, like the record head, is made with a magnetic core on which is wound many turns of fine wire. It also has a gap where the tape contacts the head: usually this gap is much narrower than the record head gap. The magnetic field from the tape links the play-back (reproduce) head core and induces a voltage in the play-back head coils. This voltage represents the output signal, which is then amplified.

Note that the tape recorder UHER 4200 used in this workshop is provided with only 2 heads, erase and record/reproduce. The latter head performs both recording and reproducing functions, depending on mode of operation of the tape recorder.

II.2.C.& D.3 FUNCTIONING OF UHER 4200 TAPE RECORDER:

UHER 4200 is a tape recorder which is commonly used in noise control work. The controls of this recorder are identified in the Figure II.2.C.& D. 1. and described below in detail.

(1) Power Switch and Tape Speed Selector:

The recorder offers four tape speeds which can be selected by means of the speed selector. For this purpose press in the selector knob and move it into the slot corresponding to the tape speed desired. This at the same time switches instrument on.

The knob of the speed selector can offer clockwise or counter-clockwise rotation and be locked both in the "Off" position and the operating position selected as shown in Figures II.2.C.& D.2.& 3. This feature prevents any possibility of incomplete corrections and enables foolproof speed selection.

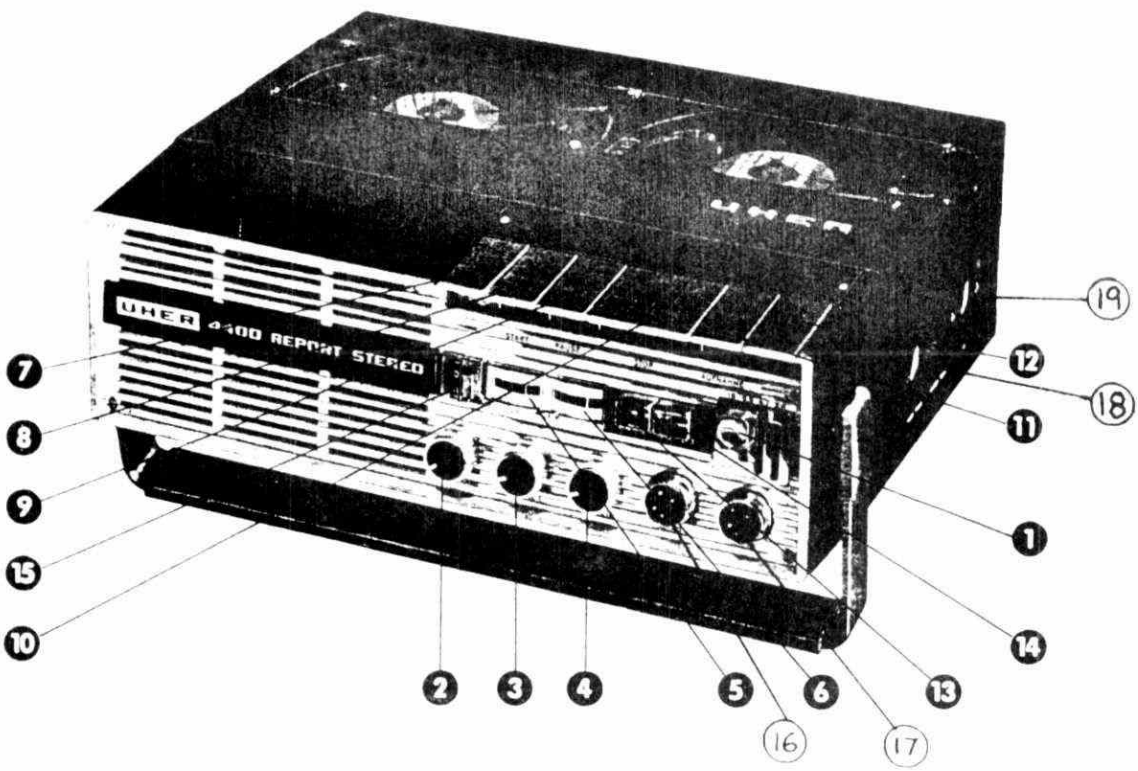


Figure II.2.C.& D.1. Controls of UHER 4200 Tape Recorder

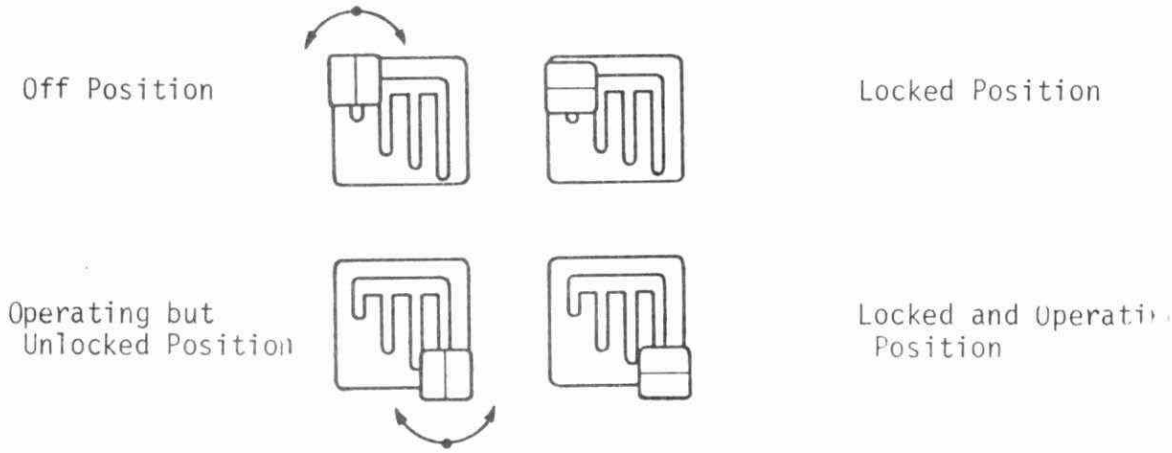
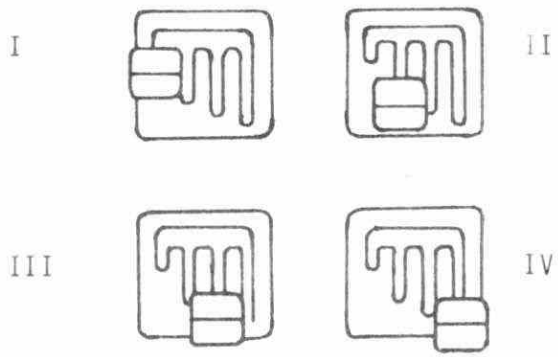


Figure II.2.C.& D.2: Speed Selector Knob in "Off" and Operating Position

Four possible positions of tape speed selector and corresponding tape speeds are illustrated in Figure II.2.C.& D.3.



I	19	cm/s	(7 1/2 ips)
II	9,5	cm/s	(3 3/4 ips)
III	4,7	cm/s	(1 7/8 ips)
IV	2,4	cm/s	(15/16 ips)

Figure II.2.C.& D.3. Various Tape Speed Settings.

(2) Volume Control:
This knob serves to control the volume of play-back or monitoring through the built-in speaker during monophonic operation.

(3) (4) Control of Recording Levels:
Being a fully stereophonic recorder, the instrument is equipped with two recording level controls, of which the left-hand one serves to control the left channel and the right-hand one the right channel. When the left knob is pulled, the illumination of both indicators is switched on. Pulling the right-hand knob permits testing the battery voltage indicated on the right-hand indicator. Both of these knobs are spring loaded.

(5) (6) Recording Level Indicators:
To permit the recording level to be accurately controlled in each channel, the instrument is equipped with two indicators. The right hand indicator also serves for battery testing.

(7) Rewind Key:
This key is used in fast rewinding of tape.

(8) Start Key:
This serves to start the tape for recording or playback.

(9) Pause Key:
This control is to briefly interrupt the feeding of tape during recording or playback mode, until it is raised again.

(10) Stop Key:
This resets all keys - with the exception of the Pause key - and stops the tape feed.

(11) Record Key:
This switches the instrument to recording mode. The tape feed is started by simultaneous depression of the start key.

(12) Forward Feed Key:
This serves to start the fast forward tape feed.

(13) (14) Track Selector Keys:
When the left-hand key is pressed, track 1 is selected for recording or playback. Depression of the right-hand key selects track 2. If both keys are depressed simultaneously, the instrument is set for stereophonic recording or playback.

(15) Tape Counter:
This monitors the changing length of the tape on the reel and facilitates the relocation of any desired passage on the tape. The counter should be reset by pressing its reset key before beginning any recording or playback.

(16) (17) Sockets marked "MICRO I" and "MICRO II":
These serve for connecting low-impedance microphones. When the remote-control microphones are used (type M519 or M819) the necessary connection for the remote control of the stopping and starting of the tape feed is automatically established.

(18) Socket marked "RADIO/PHONO":
This is combined input and output socket for connecting the recorder to the sound level meter, or level recorder input. Also it may serve for connecting radio sets, mixing consoles, record players or tape recorders.

(19) Sockets for Auxiliary Equipment marked "△":
This is to connect the power pack, battery charger or the remote start/stop control to the recorder.

II.2.C.& D.4. TAPE SPEED AND FREQUENCY RESPONSE:
Selection of tape speed depends on the purpose of recording. The following table recommends what tape speed should be used for different applications.

Tape Speed	Frequency Range	Purpose
2.4 cm/sec (15/16 ips)	40-4,500 Hz	Recording in which long playing time is more important than tonal quality.
4.7 cm/sec (1 7/8 ips)	40-10,000 Hz	Recording in which long playing times are desirable, while no particularly high demands are made of tonal quality although the latter is already very good.
9.5 cm/sec (3 3/4 ips)	40-16,000 Hz	Recordings for which high tonal quality is demanded.
19 cm/sec (7½ ips)	40-20,000 Hz	High quality recordings satisfying the most exacting demands of tonal quality.

Table 1: Different Tape Speeds and Corresponding Frequency Response of UHER 4200.

The slower the tape speed selected, the longer a given size of reel of tape will last. However, the upper frequency limit, as can be seen from the table, gets lower and lower as tape speed is reduced. To understand how this happens, recall that the degree of magnetization of the tape is proportional to the sound pressure. High frequency sounds thus involve rapid changes in the degree of magnetization. As tape speed is reduced, these changes of magnetization have to occur within shorter tape length, eventually exceeding the limits of the tape to accurately respond. The lower limiting frequency (40 Hz) is not governed by tape speed, but by other elements in the tape recording system. The upper limiting frequency is governed by tape speed, but also by other elements of the recording system.

II.2.C.& D.5 OPERATION OF TAPE RECORDER:

Threading of Tape:

In portable recorders, the tape reels must be protected against falling off the turntables. Therefore, before threading the tape, the three pronged spindle of each turntable should be pulled upwards and turned until the prongs of the stationary and the movable parts are in the position as shown in the Figure II.2.C.& D.4.

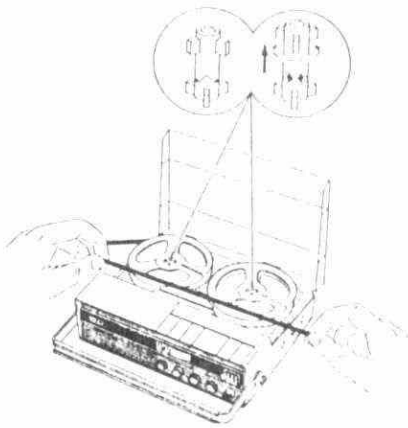


Figure II.2.C.& D.4: Positioning of the Three-pronged Spindle of Turntable.

A full reel of tape should then be placed on the left-hand turntable, an empty reel on the right-hand turntable, and the tape introduced vertically into the tape guide slot. The bright side of the leader on the matte side (emulsion side) of the tape must face inwards, towards the core of the reel. Finally, both reels should be protected against falling by turning the two three-pronged spindles clockwise or counterclockwise until they snap into position and the reels cannot be taken off.

Two Track Technique:

The "UHER 4200" works on the two-track principle, i.e. the width of the tape is shared by two tracks. Consequently there is room for a total of two tracks on the tape. For the monophonic operation, the upper half is used first. When the tape reels have been reversed, the lower half lies on top and is thus available for further recordings.

For stereophonic operation both tracks are used simultaneously.

II.2.C.& D.6 RECORDING AND SUBSEQUENT ANALYSIS OF NOISE SIGNAL:

Recording a Noise on Tape Recorder:

Normally the output signal from the measuring microphone is fed to a microphone input of a magnetic tape recorder, either directly or via some amplifying device. Sound level meters are also suited for feeding a tape recorder. A typical arrangement for recording a noise onto magnetic tape for later analysis is shown below in the Figure II.2.C.& D.5.

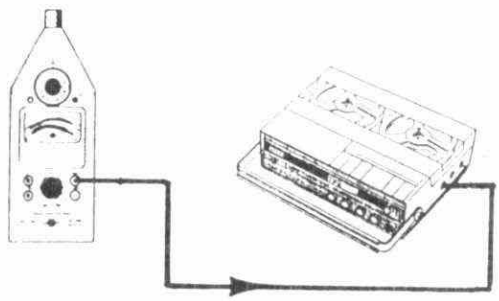


Figure II.2.C.& D.5: Set-up for Recording Noise Signal.

Here, a signal which has been amplified twice in a sound level meter (only once if it were passed through the microphone alone) is fed to the "RADIO-PHONO" socket of the recorder, having high input impedance. It is to be noted that the "RADIO-PHONO" socket accepts higher voltage signals than does the microphone socket. The recording of noise for subsequent analysis involves two steps, recording the calibration tone, and recording the noise signal. These steps are described below in that order. The sound level meter and calibrator used in this procedure are B & K 2203 and 4230 respectively, but instruments of other makes are equally adaptable for such analysis.

Step 1 - Recording Calibration Tone:

- connect output socket of the Sound Level Meter B & K 2203 with "Radio/Phono" socket of the tape recorder. Select desirable tape speed and switch on both the instruments.
- Place the Sound Level Calibrator B & K 4230 on the Sound Level Meter.
- On the meter, set the function selector to "Fast" and "Lin"; turn the transparent dial fully clockwise and adjust black dial until the figure"90" appears in the red circle. Press the button on the calibrator and the meter should indicate 4dB.
- Adjust the "ADJ" potentiometer until a deflection "0" dB is obtained.
- Turn output attenuator (transparent dial) counterclockwise by 2 steps (20 dB gain).
- Select and press desirable track selector key (say 13) of the tape recorder.
- Press the record key (11).
- Turn the recording level control (3) clockwise until the left hand indicator needle lines up at the boundary between black and red area. This will ensure that the dynamic range of the tape recorder matches the dynamic range of the Sound Level Meter (typical dynamic range of UHER 4200 is in 30 dB range).
- Recalibrate the Sound Level Meter by turning the transparent dial clockwise by 2 steps until the figure"90"appears in the red circle and by adjusting the "ADJ" potentiometer until a deflection 4dB is obtained on the scale.
- To start recording calibration tone depress the record and start keys (11) and (18) respectively, simultaneously.(For interruption of recording, press the pause key (9). When the recording is to be resumed, return the pause key to its original position).
- To end the recording of calibration tone press the stop key (10). The Record and start keys will then snap back into their original position.
- Withdraw the calibrator from the Sound Level Meter microphone gently.

Step 2 - Recording Noise Signal:

- On the meter set function selector to "Fast" and "Lin".

- Set the Sound Level Meter attenuator to appropriate sound levels to be measured.
- Document the Sound Level Meter attenuator setting (say X).
- Simultaneously depress the record and start keys to commence recording of the noise signal.
- Press the stop key at the end of recording of noise signal.
- It is desirable to record calibration tone again at the end of the noise signal recording by following Step 1.

NOTE:

Recording the calibration tone and the noise signal should be carried out at the same position of gain control of the tape recorder. Thus, the gain control knob must not be altered once it has been set during calibration tone until the noise signal recording is successfully completed. Also, the sound level meter attenuator setting must be recorded for use in subsequent playback analysis.

Playback of the Recorded Signal through Sound Level Meter:

The arrangement for playing back the recording and reading the levels of recorded sounds on sound level meter, is shown in Figure II.2.C.& D.6.

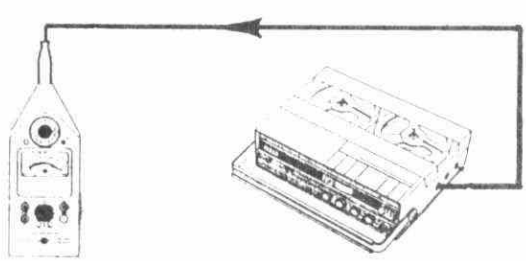


Figure II.2.C.& D.6: Set-up for Playing Back the Recorded Signal.

Here an electric signal from the tape recorder ("Radio/phono" socket) is fed to the Sound Level Meter which is used as an amplifier and indicator. A systematic procedure to be followed during playback is listed below.

- Connect "Radio/Phono" socket of the tape recorder with the Sound Level Meter microphone input through an input adaptor.
- Select the appropriate tape speed and switch both instruments on.
- Press the selector key for the recorded track.
- Press start key to start playback of the calibration tone at the beginning of the tape.
- On the meter, set function selector to "Fast" and "Lin"; and turn the transparent dial fully clockwise and adjust black dial until indicating meter deflects in the upper 10 dB of the scale. Using a small screwdriver adjust the "ADJ" to give a meter scale reading of 4dB.
- Adjust desired playback volume by means of volume control (2) and read out Sound Level Meter deflection. The reading on the meter scale added to the value of attenuator setting documented previously during recording (called X) gives the sound levels.

NOTE:

If other calibrators such as B & K pistonphone type 4220 are used, the attenuator settings should be adjusted accordingly. (Recall that this calibrator delivers 124dB at 250 Hz.)

II.2.C.& D.7 FREQUENCY ANALYSIS OF THE RECORDED NOISE SIGNAL

The same set-up as shown in the Figure II.2.C.& D.6 is used here, the only difference being that an octave filter set is incorporated with the sound level meter for frequency analysis. The analysis procedure is outlined below.

- Connect the Sound Level Meter to an octave filter set (B & K type 1613).
- Turn function selector of the Sound Level Meter to the position "External Filter".
- Select the individual octave bands (the numbers on the filter set indicate pass-band centre frequency) and read out corresponding octave sound pressure level.

- Take readings of Sound Pressure Level in each octave band and tabulate the results in the data sheet of Figure II.2.C.& D.7.

Note: Please note that completed data sheet must be handed in at the end of this workshop period.

II.2.C.& D.(Workshop)

Data Sheet 1

Trainee's Name:

Measurement Parameter	Levels Measured Directly in Field (I)	Levels Measured from Tape Analysis (II)	Difference between Columns (I) and (II)
A scale			
B scale			
C scale			
Linear scale			
63 Hz band			
125 Hz			
250 Hz			
500 Hz			
1000 Hz			
2000 Hz			
4000 Hz			
8000 Hz			
16000 Hz			
31500 Hz			

Question: Are there any differences between the levels by the two methods, and if so, why?

Answer:

Figure II.2.C.& D.7

SUBJECT:
ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.3.A. (Procedures)

Objectives:

Trainee will be able to:

1. Indicate the significance of acoustical measurement standards and name the institution involved in developing them;

2. Outline the measurement procedure of the following noise sources according to the following standards, also indicating recommended sound level limits:

   (a) residential air conditioners in accordance with NPC-116,

   (b) construction equipment - paving breakers, portable air compressors, crawler drills, mobile excavation equipment and impact pile drivers in accordance with NPC-115.

   (c) air blast overpressure levels and ground vibration levels in accordance with NPC-119.

II.3.A.1. ACOUSTICAL MEASUREMENT STANDARDS

Measurement standards are important in any science in order to ensure that the quoted result is derived in meaningful circumstances and with appropriate measurement accuracy. In acoustics, the "meaningful circumstances" invariably involve a definition of the operating mode of the source and of the geometry of the test site, while "appropriate measurement accuracy" refers generally to the accuracy of the instruments and the weather conditions that affect that accuracy. Always remember that an acoustics measurement can be worthless if these matters are not given due attention.

Many organizations prepare these standards, and the following are mentioned in the model by-law.

Canadian Standards Association (CSA)
American National Standards Institute (ANSI)
International Organization for Standardization (ISO)
Society of Automotive Engineers (SAE)
Compressed Air and Gas Institute (CAGI)
European Committee of Manufacturers of Compressed Air Equipment (PNEUROP).

Some standards simply describe the accuracy of measuring instruments. Others specify a measurement procedure.

II.3.A.2. MEASUREMENT PROCEDURES AND SOUND LEVEL LIMITS:

(a) Residential Air-Conditioners in Accordance with NPC-116:
NPC-116 is a Ministry of the Environment publication referring to sound level measurements of air-conditioners of 12.3 KW (42,000 BTU/hr) capacity or less, when installed in residential dwellings.

The sound level must not exceed a certain value at a "point of reception", which is defined as a point on the premises of a person where sound or vibration originating other than on those premises is received, and also any point in a public place where sound or

vibration is received. The maximum permissible levels from the By-law Publication NPC-116 are reproduced below in Table 2.

Date Equipment Installed	Level, dBA
After Jan. 1st, 1976	50
After Jan. 1st, 1980	45

Table 2 : Maximum Permissible Levels of Residential Air Conditioner as Measured at the Point of Reception in dBA.

Where the Municipality has drawn up a noise zone map along the lines of Table 9 and the level set for a particular area exceeds the levels set in Table 2 then this higher level shall be the appropriate limit. This is to ensure that one is not trying to measure an air conditioner which is producing sound levels below the existing ambient.

(b) Construction Equipment in Accordance with NPC 115:
The following is an extract from the draft NPC-103 concerned with the measurement of on-site noise from construction equipment. First, the sound measurement procedure for construction equipment is listed, followed by the maximum permissible sound level limits of individual machines.

1. PURPOSE

Standard test procedures are provided for the measurement of airborne sound emitted by construction equipment operating on construction sites. This is to determine the maximum noise emitted by the individual equipment under normal operating conditions.

2. SCOPE

Procedures are provided for: Paving breakers; portable compressors; and track drills; and powered mobile-or stationary-equipment of 20 rated bhp and over; such as dozers, crawler tractors, loaders, power shovels, cranes, scrapers, off-highway trucks, power excavators, etc., excluding powered hand held tools and pile drivers.

3. INSTRUMENTATION

- A sound level meter which meets the requirements of CSA Z107-1 Type 2 (General-Purpose Sound Level Meter).
- A sound level calibrator.
- A windscreen shall be used.

4. TEST SITE

- It is desirable that the test site be a flat, open space free of any large reflecting surfaces, such as signboard, building, parked vehicles or hillside, located within 15 m. of either the microphone or the equipment being measured.
- The **ambient sound level (including wind effects)** due to sources other than the equipment being measured shall preferably be **at least 10 dBA lower** than the sound level with the equipment operating. When the difference is less than 10 dBA the correction factors given in Figure II.3.A.1. shall be applied. **If the difference between the sound level measured with the equipment operating and the ambient sound level is less than 3 dBA, a valid measurement cannot be obtained.** Ambient sound levels shall be obtained in dBA with the **slow response** setting of the meter or reading device.

5. SOUND LEVEL LIMITS

The maximum allowable sound level limits referred to in the By-law Publication NPC - 115 are presented in this sub-section in tabular form. The measurement procedure referred to in the tables, CAGI-PNEUROP and SAE J88 refer to standard tests which can only be carried out in a very-controlled environment, and which are intended for certification purposes, i.e. industry measurements. The procedures described above are essentially approximations to these standards for use in the field. Because these procedures are approximations to the ideal, some tolerance must be applied when comparing such measurements with these tabulated levels - a recommended tolerance is 3 dBA.

It is quite possible that the conditions described in the above procedure cannot be found on site. If so, meaningful measurement cannot be made on site.

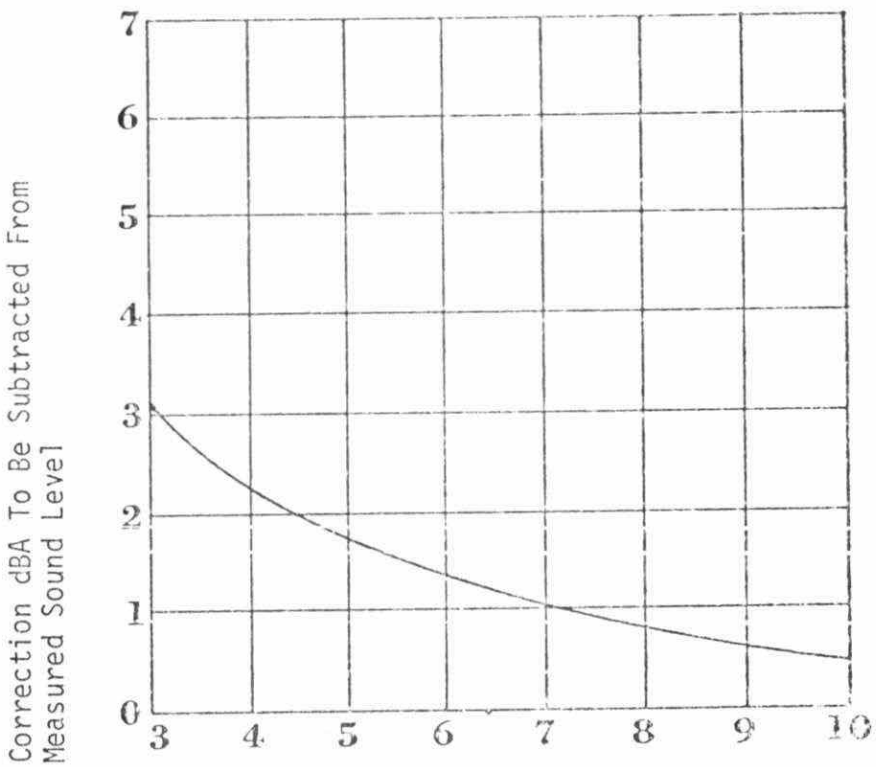


Figure II.3.A.1.-Difference Between Background Sound and Total Sound, dBA

MEASUREMENT OF SOUND FROM PAVING BREAKERS

1. Operation of Equipment

   - The machine is to be operated in its normal operating position, and held down firmly.
   - The breaker shall be operated at the rated pressure or the normal operating pressure if higher than the rated pressure.

2. Microphone Locations

   A preliminary survey shall be taken all around the machine at a preferred distance of 7 m.(23 ft) from the outline of the paving breaker to establish the direction of the maximum level. The microphone locations shall be in this direction and in four other directions equispaced around the paving breaker. At all locations, microphone height above the ground plane shall be in the range 1.2 to 1.5 m. (4 to 5 feet).

3. Sound Level Measurement

   - Ambient noise levels at the specified microphone locations, without the paving breaker operating.
   - Overall sound level in dBA with the slow response setting of the meter at the specified microphone locations.

The maximum sound level limits for pneumatic pavement breakers are listed in Table 3.

Area of Usage	Date of Manufacture	Sound Level as Measured Using CAGI-PNEUROP Test Code. dBA @ 7m	
		Weight Greater than 32 Kg	Weight Less than 32 Kg
Quiet Zones	Existing Units	85	85
Other Zones (within 600 m of residential, commercial or industrial structure or quiet zone)	Jan. 1st, 1976	89	85
	Jan. 1st, 1980	85	85

*CAGI-PNEUROP Test - Code for the measurement of sound from pneumatic equipment (also known as A.N.S.I.-S.5.1 - 1971)

Table 3 : Sound Level Limits for Pneumatic Pavement Breakers

MEASUREMENT OF SOUND FROM PORTABLE AIR COMPRESSORS AND CRAWLER DRILLS

1. Operation of Equipment

   - Portable Compressors:
     The compressor should be tested delivering its rated output, and its normal operating pressure.
   - Crawler Drills:
     The machine on test should be operated normally, and at rated or normal operating pressure with the feeding and rotational mechanisms set for maximum or normal drill performance (drilling should be done in an up-right position).

2. Microphone Locations

   A preliminary survey shall be taken all around the machine at a preferred distance of 7 m. (23 ft.) from the outline of the equipment to establish the direction of the maximum sound level. The microphone locations shall be in this direction and in four other directions equispaced from each other and from the centre of the sides of the equipment. At all locations, microphone height above the ground plane should be in the range 1.2 to 1.5 m. (4 to 5 feet).

3. Sound Level Measurement

   - Ambient noise level, at the specified microphone locations, without the equipment operating.
   - Overall sound level in dBA with the slow response setting of the meter or reading device at the specified microphone locations.

   The maximum sound level limits for portable compressors and crawler drills, are given in Table 4 and 5 respectively.

Table 4: Sound Level Limits for Portable Air Compressors

Area of Usage	Date of Manufacture	Sound Level as Measured Using CAGI-PNEUROP Test Code dBA @ 7m	
		Capacity Less than 10 m^3/min	Capacity Greater than 10 m^3/min
Quiet Zones	Jan. 1st, 1976	75	75
	Jan. 1st, 1980	70	70
Other Zones (within 600 m of; residential commercial or industrial structure or quiet zone)	Jan. 1st, 1976	80	80

Table 5 : Sound Level Limits for Crawler Drills

Area of Usage	Date Effective	Sound Level dBA at 7 m.	Measurement Procedure
Quiet Zones	Jan. 1st, 1976	97	CAGI-PNEUROP*
	Jan. 1st, 1978	87	
Other Zones	Jan. 1st, 1976	103	
	Jan. 1st, 1978	97	

* CAGI-PNEUROP Test - Code for the measurement of sound from pneumatic equipment (also known as A.N.S.I. - S.5.1. - 1971)

MEASUREMENT OF SOUND FROM POWERED OR STATIONARY MOBILE EQUIPMENT

1. Tests Required

- Stationary Equipment

  Stationary equipment should be operated at a combination of load and speed which are typical of its normal use and which produces the maximum sound level without violating the manufacturer's operation specifications.

- Mobile Equipment

  Mobile equipment shall be measured in a stationary mode with the engine operated at maximum normal attainable speed with no load.

2. Microphone Locations

The microphone shall be located in at least four locations at a distance of 15 m. (50 feet) from the four major surfaces of the equipment (four major surfaces refer to front, rear and sides of an imaginary box that would just fit over the machine including the tires or tracks but does not include attachment items such as buckets, booms, etc.). At all locations, microphone height above the ground plane shall be in the range 1.2 to 1.5 m. (4 to 5 feet).

3. Sound Level Measurement

- For the stationary test record, the highest sound level obtained in dBA with the slow response setting of the meter or reading device at the specified microphone locations due to the equipment operation. The applicable reading will be the highest recorded reading at one of the microphone locations.
- Ambient noise level without the equipment operating shall be taken at the specified microphone locations.
- The recorded dBA value shall be the highest of the recorded values in the test.

The maximum sound level limits are given in Table 6.

Area of Usage	Specification Sound Level as Determined Using SAE J88a dBA @ 15 m		
	Date of Manufacture	Less than 100 HP (SAE)	Greater than 100 HP (SAE)
Quiet Zones	After Jan. 1st, 1976	83	85
Other Zones (within 600 m of; residential, commercial or industrial structure, or quiet zone)	After Jan. 1st, 1976	85	88
	After Jan. 1st, 1980	83	85

Table 6 : Sound Level Limits for Excavation Equipment

The above levels apply to tracked dozers, back-hoes, front end loaders, scrapers, graders or other excavation equipment capable of being used for similar application.

MEASUREMENT OF SOUND FROM IMPACT PILE DRIVER

The procedure for pile drivers is under preparation, but will consist essentially of measuring the peak sound level in dBA at a distance of 15m. from the pile, having made sure that there are no major reflecting surfaces within 15m. of the sound level meter.

The maximum sound level limits are given in Table 7 below.

Area of Usage	Date of Manufacture	Peak Level dBA at 15m	Measurement Procedure
Quiet Zones	Jan. 1st, 1976		Publication NPC-103
	Jan. 1st, 1978		"
Other Zones	Jan. 1st, 1976		"
	Jan. 1st, 1978		"

Table 7 : Sound Level Limits for Impact Pile Driver

(c) Air Blast Overpressure Levels and Ground Vibration Levels in Accordance with NPC - 119

1. Overpressure (Concussion)

There are two limits for concussion: a 'cautionary limit' and an absolute 'limit'. If the cautionary limit is routinely exceeded, then a blasting operator is required to have his blasting operation monitored on a routine basis. This cautionary limit, as presently drafted, is 128 dB peak.

The 'limit' is presently drafted as 136 dB peak which defines an acoustic intrusion.

2. Ground Vibration

The ground vibration limit is presently drafted as 50 mm/s peak particle velocity. This is a limit on the total vector sum. Normally ground vibration is measured by monitoring vibration velocity in 3 directions (axes) mutually at right angles. To obtain the instantaneous total velocity, the 3 velocity vectors must be summed (vectorially).

3. Measurement Procedure

The following is an extract from draft Publication NPC-103 Procedures, dealing with blasting concussion (overpressure) and ground vibration.

SOUND AND VIBRATION MEASUREMENTS FROM THE BLASTING OPERATIONS IN QUARRIES

1. Scope

This publication describes the procedures to be used when measuring overpressures and ground vibration due to quarry blasting operations.

2. Instrumentation

Overpressure Level

- A sound level meter shall be used which meets the specifications of I.E.C. 179 for Type 1 meters only and subsection 4.5.1 of I.E.C. 179A supplement to I.E.C. 179. (Appendix I of Section II.1.C.).
- A sound level calibrator shall be used.
- A windscreen shall be used.

Ground Vibration

- A system shall be employed which can record instantaneous vibration velocity in 3 (preferably orthogonal) directions simultaneously or the total vector sum of velocity components and which meets specifications set out in Publication NPC 104 Standards.

Note: Calibration of the system as used in the field shall be carried out not less than once per calendar year.

3 Procedure

Measurement Location

Overpressure

The measurement location shall be within 7 m. of a residential structure outside the property on which the blasting operation takes place, but greater than 1 m. from any surface of that structure.

Structures other than the residences of concern, with large reflecting surfaces such as walls or solid fences should not be closer than 7 m. to the measurement location.

Ground Vibration

Vibration measurements shall be made at the residence of concern either (i) on a part of the structure at or below grade, preferably on a basement floor close to an outside corner or (ii) on or below ground outside the structure.

Measurement Procedures

Overpressure

- The microphone shall be located at a height of 1.2 - 1.5 m. above the ground.
- The meter shall be set for 'Peak' response (using a 'hold' facility if available) and 'Linear' (i.e. flat) weighting.
- The approximate wind speed and direction (relative to the line from the blast to the measurement location) shall be noted.
- The ambient sound level in dBA and/or dB (Linear) may be noted in terms of a range of levels (optional).
- The sound level meter shall be calibrated before and after the measurements.

Vibration

- The vibration transducer shall be securely attached to part of the structure or to a solid medium, if outside, so as to prevent movement of the transducer relative to the structure or ground during the vibration.
- Where 3 vector components are recorded individually it is preferable to orient the transducer such that the three axes of measurement are (i) vertical, (ii) radial (i.e. along a horizontal line joining the place of the blast to the location of measurement), (iii) transverse (i.e. along a horizontal line at right angles to the line joining the place of the blast to the location of measurement).

4. Tolerances

Overpressure

The instrumentation specifications referred to above preclude the registering of levels above the actual for blast concussion. Instrument reading errors however can be incurred particularly if no 'hold' facility is available.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.3.B.& C.(Procedures)

OBJECTIVES:

Trainee will be able to:

1. Describe the scope of the Environmental Protection Act as it applies to sound and vibration;
2. Indicate the relationship between the EPA and the Model Municipal Noise Control By-law;
3. Indicate the jurisdiction and some applications of the above by-law;
4. Indicate noise situations not covered by the by-law;
5. Describe how the by-law may be administered in co-operation with the Province;
6. Indicate the likely role of the Noise Control Officer in by-law administration.

II.3.B.& C.1 SOUND AND VIBRATION IN THE EPA:

The **Environmental Protection Act, 1971**, as amended, controls sound and vibration in a number of ways; the most important of which are the following:

Control Order (Sections 6, 70, 71, 72, 73)

The Province may issue a Control Order to require that a sound source be silenced, stopped, or altered in its manner of operation **if the sound levels are excessive.**

Stop Order (Sections 7, 74, 75, 76)

The Province may issue a Stop Order to require that a source of vibration or sound be stopped if it constitutes **an immediate danger to health or property.**

Certificate of Approval (Sections 8, 10, 11)

No person may install or alter noise emitting equipment without obtaining the Province's certificate of approval.

Prohibition (Section 14)

No person may emit sound or vibration into the natural environment that:

(a) causes or is likely to cause **impairment of the quality of the natural environment** for any use that can be made of it;
(b) causes or is likely to cause **injury or damage to property or to plant or animal life;**
(c) causes or is likely to cause **harm or material discomfort** to any person;
(d) adversely affects or is likely to **adversely affect the health** of any person;
(e) impairs or is likely to **impair the safety** of any person; or
(f) renders or is likely to **render any property or plant or animal life unfit for use by man.**

Work Order (Section 18)

When the Province considers that it is necessary or advisable for the protection of the natural environment, it may order an emitter to obtain equipment and materials to alleviate any sound or vibration.

Motor Vehicles (Sections 23, 24)

No person may install, sell or operate a motor vehicle that does not comply with regulations which may be made under Section 94. No person may remove, except for repair or replacement, any sound control device. (See Regulation 15 below.)

Provincial Officer (Sections 82, 83, 84, 85)

The Province may designate people to be provincial officers who shall have the right to survey noise and inspect records and to apply to a provincial judge for an order to allow entry.

Confidentiality (Section 87)

Certain matters must be kept confidential.

Regulations (Section 94)

The Province may issue regulations setting noise limits and other noise controls.

Municipal By-law (Section 95)

Municipalities may, with the approval of the Province, pass by-laws controlling sound and vibration (see II.3.B.& C.2).

Convictions (Section 102)

The maximum fine for a first conviction is $5,000. The maximum fine for a subsequent conviction is $10,000. for every day or part thereof.

Regulation 15, Section 6 of The Environmental Protection Act, 1971

This Section of the Act is quoted below:

"No person shall cause or permit to be caused **the emission of any air contaminant** to such extent or degree as may,

(a) cause discomfort to persons;

(b) cause loss of enjoyment of normal use of property;

(c) interfere with normal conduct of business; or

(d) cause damage to property. R.R.O.1970, Reg. 15, s. 6."

II.3.B.& C.2. EPA AND THE MODEL MUNICIPAL NOISE CONTROL BY-LAW:

The Environmental Protection Amendment Act, 1974 (No. 2) provides that:

(1) The council of a local municipality may, subject to the approval of the Minister, pass a by-law,

(a) regulating or prohibiting the emission of sound or vibration;

(b) provide for the licensing of persons, equipment and premises, or any of them, with respect to the emission or sounds or vibrations;

(c) prescribe maximum permissible levels of sounds or vibrations that may be emitted;

(d) prescribe procedures for determining the levels of sounds or vibrations that are emitted;

and such by-laws may make different provisions for different areas of a local municipality and may make provision for exempting any person, equipment or premises from any provision of the by-law for such period of time and subject to such terms and conditions as may be set out or provided for in the by-law.

(2) A by-law passed by the council of a local municipality pursuant to sub-section 1 may adopt by reference, in whole or in part, with such changes as the council considers necessary, any code, formula, standard or procedure, and may require compliance with any code, standard or procedure, so adopted.

To assist municipalities, the Province has prepared a model by-law which, after amendment in the light of comments from municipalities and others, will be issued for municipalities to enact at their discretion.

It is intended that the by-law meet the requirements of municipalities of all sizes, provide comprehensive control for most known sound and vibration problems, permit flexibility to meet local needs and resources and provide a unifying base for noise control across the Province. The prerogative for approval for a municipal noise control by-law is assigned to the Minister by the legislation.

The draft Model By-law consists of four parts supported by technical appendices:

Part I Section 1 provides layman explanations and technical definitions for the terms used in the by-law.

Part II Sections 2 through 8 deal with the appointment, certification, duties and authority of the Noise Control Officer and his relation to the municipal corporation.

Part III Sections 9 through 22 include the prohibition and penalty provisions and provide details of **what constitutes an "acoustic intrusion"** in terms of a wide variety of sound sources and thereby sets limits in terms of noise levels.

Part IV Section 32 deals with exemptions.

II.3.B.& C.3. JURISDICTION AND APPLICATIONS OF THE BY-LAW:

A summary of the pertinent functions of the Model Municipal Noise Control By-law is provided below:

(1) The by-law will permit a Municipal Council to exercise broad environmental noise control at the local level under the powers granted by The Environmental Protection Act, 1974.

(2) The by-law specifically **prohibits or curtails some noise activities in sensitive areas of the community at certain times of the day.** Sources of acoustic intrusions that are suggested for control in this way include:

all auditory signalling devices, loud speakers, street selling by outcry, loading and delivery, construction, discharge of firearms, animal noises, use of explosives, idling rail equipment on private property, car washes, all-terrain vehicles, people noises, parties, gatherings, power tools, venting of high pressure gases.

(3) The by-law **prohibits outright** acoustic intrusions emanating from;

tire squeal, braking noises, faulty mufflers, racing vehicles, miscellaneous vehicle noises, unwarranted idling.

(4) Acoustic intrusions from the following sources are **limited by noise level, and/or time of day and municipal zone**:

air conditioners - domestic and commercial, power mowers and power tools, motorized conveyances, blasting and vibration, industrial and commercial noises.

(5) The by-law **fixes the maximum noise levels permitted in residential areas on the basis of the equivalent constant**

energy level. This dBA level takes into account periodic noise fluctuation that may cause annoyance. (L_{eq})

(6) Under the by-law, the Council may exempt any person from prosecution for many of these provisions for a period up to six months.

II.3.B.& C.4. NOISE SITUATIONS NOT COVERED BY THE BY-LAW:

These include those not under provincial jurisdiction, as covered in the sub-section I.1.B. of Environmental Acoustics Technology-I.

- Noise from the operation of aircraft;
- Noise from the operation of trains;
- Noise from the operation of boats;
- Noise from Federal Government installations;

Noise from a neighbouring municipality is a particular case where Provincial intervention may be required.

II.3.B.& C.5. CO-OPERATION WITH THE PROVINCE IN BY-LAW ADMINISTRATION:

The Province has the following part in by-law administration:

1. The enabling legislation, the E.P.A., is a Provincial Act.
2. The Model Municipal By-law was prepared by the Province.
3. By-laws to be passed by municipalities must have Ministerial approval.
4. Certain duties of by-law administration must be performed by persons having a Certificate of Competency issued by the Minister.
5. The sound level map specified in the by-law must be submitted to the Minister when first prepared, and every three years thereafter.
6. Periodic reporting must be made to the Minister on all aspects to do with by-law administration.
7. The by-law contains many references to NPC Publications which the Province will issue and may, from time to time, revise.
8. The Province is providing a training course in acoustic technology and noise control enforcement procedures.
9. Audiometric testing will be provided for all designated municipal employees during the training course.

II.3.B.& C.6. ROLE OF THE NOISE CONTROL OFFICER:

The Model By-law suggests certain duties for the municipality's Noise Control Officer. It may be assumed that the Assistant Noise Control Officer and the Noise Control Investigator will perform services to assist the Noise Control Officer.

The following are some extracts from the model by-law which refer to the Noise Control Officer's duties at the option of Council.

Part II, 2 Noise Control Officer

Council will designate a Noise Control Officer to administer this by-law. The Noise Control Officer shall possess a valid Class 3 Certificate. With the approval of Council, the Noise Control Officer may engage the services of such assistants and such investigative personnel, as he considers necessary. An Assistant Noise Control Officer shall possess a valid Class 2 Certificate and a Noise Control Investigator shall possess a valid Class 1 Certificate.

Part II, 3(2) Co-operation

Every municipal officer, servant and employee shall co-operate with the Noise Control Officer to the fullest extent in enforcing this by-law.

Part II, 3(4) Municipal Employees

If at any time the Noise Control Officer believes, on reasonable grounds, that a municipal officer, servant or employee is setting or enforcing standards or otherwise performing his duties not in conformance with the policy of noise reduction and control embodied in this by-law, he may require such person to consult him as to the manner in which this by-law and the policy embodied herein relate to the duties of such person.

Part II, 3(5) Project Approval

No municipal officer, servant or employee shall issue or grant any exemption, permit, licence or approval for any new work or undertaking or any change in

an existing work or undertaking, when such work or undertaking or such change may result in the emission of noise, without first consulting the Noise Control Officer.

Part II, 4(1) Building Permits

No municipal officer, servant or employee shall issue or grant any exemption, permit, licence or approval for any construction to be done in connection with a proposed or existing building, without first either obtaining the written approval of the Noise Control Officer or being supplied by the applicant with the written approval of Council.

Part II, 4(2) Approval of Noise Control Officer

The Noise Control Officer shall not provide the written approval mentioned in subsection 1 until and unless he is provided with evidence satisfactory to himself that, at any point on the proposed site of a new building or of an alteration to an existing building, including any point above ground which will be occupied by the proposed building or alteration, the sound criteria specified in Publication NPC 105 as shown as applicable to that type of building are met.

Part II, 4(3) Approval of Noise Control Officer

The Noise Control Officer shall not provide the written approval mentioned in subsection 1 until and unless he is provided with evidence satisfactory to himself that both the acoustical considerations incorporated into the building plans and also the specifications of the noise insulation materials and techniques intended to be incorporated into the building or the construction of the building are in accordance with the relevant provisions of the National Building Code and the Ontario Building Code and Publication NPC 106.

Part II, 5(1) Occupation

No municipal officer, servant or employee shall issue or grant any exemption, permit, licence or approval which authorizes the occupation or use of any building for which approval was required under subsection 1 of section 4 unless he is provided either with a further written approval as to the occupation or use of the building from the Noise Control Officer or with the written approval of Council obtained by the applicant.

Part II, 5(2) Approval of Noise Control Officer

The Noise Control Officer shall not provide the approval to occupy or use, mentioned in subsection 1 until and unless he is provided with evidence satisfactory to himself that the building has been constructed in accordance with the plans and specifications mentioned in subsection 3 of section 4 and, for the purposes of this subsection, the building shall be deemed to have been constructed in accordance with the aforesaid plans and specifications incorporated in the construction of the building would have been acceptable to the Noise Control Officer for the purposes of subsection 3 of section 4 had such deviations been included in the plans and specifications submitted to him for such purposes.

Part II, 8(1) **Powers of Noise Control Officer**

In order to further the policy of this by-law the Noise Control Officer may have the power to:

(a) **Studies**

Conduct or cause to be conducted studies, research, and monitoring related to noise.

(b) **Education**

Conduct programmes of public education regarding the causes and effects of noise and encourage the participation of the public in such programmes.

(c) **Co-ordination and Co-operation**

Co-ordinate the noise control activities of all municipal officers, servants and employees and co-operate with municipal, provincial or federal agencies to further the policy embodied in this by-law.

(d) **Recommend Contracts**

Where appropriate,recommend that the Municipality enter into contracts for obtaining necessary technical or enforcement services.

(e) **Project Reviews**

Consult with other municipal officers, servants and employees for the purposes of this by-law.

(f) **Reports**

Make such reports to Council concerning his duties and matters related to noise and this by-law as he sees fit or as Council may require.

(g) **Consultation**

Consult the Noise Pollution Control Section of the Pollution Control Planning Branch of the Ministry of the Environment with respect to any matter relating to his duties or the enforcement of this by-law.

Part II, 8(2) Duties of Noise Control Officer

In order to further the policy embodied in this by-law the Noise Control Officer is required to:

(a) **Enforcement Procedures**

Develop administrative procedures which will provide for effective enforcement of this by-law.

(b) **Recommendations**

Recommend changes to this by-law so that it is not in conflict with related federal or provincial legislation or regulations, and so that it is consistent with developments in acoustical technology.

(c) **Advice**

Provide council with such advice as it requires for its deliberations with respect to the acoustical aspects of any matter.

(d) **Traffic Map**

Develop, or cause to be developed, a map of the Municipality showing patterns of traffic flow for the purpose of advising Council in its deliberations with respect to the regulation of traffic and making recommendations to Council in that regard.

(e) **Sound-Level Map**

Develop, or cause to be developed, a sound level map of the Municipality. A copy of such map when first prepared, and after each updating, at least once in every three years, shall be delivered to the Minister. The techniques employed in developing such a **map shall be consistent with and at least as accurate as those techniques set out in Pubication NPC 109.**

(f) **Periodic Reports**

Meet, at least once every three calendar years, with the designate of the Minister, and discuss with him the techniques employed in the preparation of the sound level map of the Municipality, acoustical matters shown on the municipal sound level map or otherwise, and other matters relating to the duties of the Noise Control Officer and the enforcement of this by-law.

(g) **Record Keeping**

Keep such records with respect to complaints of noise and the enforcement of this by-law and make such annual returns to the Minister as are specified in Publication NPC 111.

(h) Instrumentation

Procure, maintain and utilize such instruments and related equipment as are necessary in the fulfillment of his duties and the enforcement of this by-law, selected from the procedures and standards approved in, or appearing in Publication NPC 103 and Publication NPC 104 respectively, and designated therein as suitable for the purposes of this by-law.

(i) Standards

Determine the procedures and standards most suitable for the fulfillment of the duties of the Noise Control Officer and the enforcement of this by-law, selected from the procedures and standards approved in, or appearing in Publication NPC 103 and Publication NPC 104 respectively, and designated therein as suitable for the purposes of this by-law.

For ready reference,the schedule of these publications is presented on the next page.

SCHEDULE OF NPC PUBLICATIONS

Number	Publication Title
NPC 101	Definitions
NPC 102	Certificate
NPC 103	Procedures
NPC 104	Standards
NPC 105	Land Use Criteria
NPC 106	Building Acoustical Insulation & Planning
NPC 107	Noise Emission From Products
NPC 108	Traffic Map
NPC 109	Sound Level Map
NPC 110	Periodic Reports
NPC 111	Record Keeping and Annual Returns
NPC 112	Instrumentation
NPC 113	Construction Sound Control Devices
NPC 114	Mufflers
NPC 115	Construction Equipment
NPC 116	Air Conditioners
NPC 117	Domestic Power Tools
NPC 118	Motorized Conveyances
NPC 119	Blasting
NPC 120	Sound Level Limits
NPC 121	Sound Within Buildings
NPC 122	Tires and Wheels
NPC 123	Vibration
NPC 124	Impulse Sounds
NPC 125	Guideline on Duties of Noise Control Officer
NPC 126	Guideline on Aircraft Noise
NPC 127	Guideline on Very Low Frequency Sound and Vibration Measurement
NPC 128	Guideline on General Procedures
NPC 129	Guideline on Selection of Zones
NPC 130	Guideline on Transportation Noise

SUBJECT:

ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.3.D. (Procedures)

OBJECTIVES:

Trainee will be able to:

1. Explain general procedure to be followed in municipal noise investigation;
2. Indicate general information sought when interviewing complainant and noise producer including investigator's assessment of noise situation;
3. Name and demonstrate the use of forms to document field measurement data;
4. Use the flow charts to determine an acoustic intrusion;
5. Outline uses of maintaining complaint statistics.

II.3.D.1 GENERAL PROCEDURE OF MUNICIPAL NOISE INVESTIGATION :

A noise-complaint investigation may be described as the work performed to analyze and report a noise situation in order to establish how to proceed further towards an effective abatement.

An investigation will normally be conducted in two phases, the first being the preliminary investigation. This involves interviewing the complainant and the noise producer, and an assessment of the situation by the investigator.

The preliminary investigation should usually be sufficient to establish whether the LOCAL MUNICIPAL NOISE CONTROL BY-LAW does in fact cover the situation. If it does, this visit may, in simple cases, be all that is needed to establish if the sound is excessive according to the by-law. In complex situations, a subsequent investigation will usually be necessary.

A useful procedure prior to interviewing the complainant and the noise producer is to take a walk around the area of the complaint. This may result in determining the actual noise source or other contributing noise sources. This walk also enables the investigator to appreciate the local environment, and, as a result, he is better equipped to discuss the problem at initial interviews with the complainant and the noise-producer.

The usual first step in a noise investigation is to contact the complainant. This will make the complainant aware that his/her complaint is being responded to, and, in most cases, will enable the investigator to obtain more specific details of the complaint.

Before visiting a private residence, it is courteous to phone to ensure that a visit will be convenient. Should the investigator be delayed or unable to keep an appointment

it is again courteous to phone and inform the complainant of this.

At any interview the investigator should ensure that his official position and name are known, by presenting his identification card.

As a number of separate items are covered in an investigation, various forms have been prepared to help the investigator obtain the information it is usually necessary to seek. These forms may be supplemented by additional information, at the discretion of the investigator, and the forms should, in any case, be supplemented by maps and photographs covering the area and showing pertinent locations and source(s). These forms are discussed below.

II.3.D.2 INTERVIEW OF COMPLAINANT, NOISE PRODUCER AND INVESTIGATOR'S ASSESSMENT OF NOISE:

Complainant Interview Report:

To assist the investigator in obtaining the pertinent information on a complaint, the COMPLAINANT INTERVIEW FORM (shown in Figure II.3.D.1) should be completed, though preferably not by a formal question-and-answer technique while with the complainant. The investigator should proceed on a line of questioning which will determine the cause of the complaint, the nature of the noise and its likely source, etc. Precise indication of the time that a noise occurs may be crucial in tracing a source. If a noise may be heard at the time of the visit, the investigator should have the complainant point it out to him. The investigator should also ensure that he has the correct name, title (if any), and initials of the complainant, the complete address and telephone number.

INVESTIGATION NUMBER

Date: _____

INVESTIGATION REPORT
COMPLAINANT INTERVIEW

NAME: _____

ADDRESS: _____ PHONE _____

_____

1. TYPE OF NOISE: (i) _____
(ii) _____
(iii) _____
(iv) _____

2. TIME(S) OF NOISE:

Noise	Continuous Yes or No	Occasional Yes or No	Usual limits of occurrence e.g. 9 a.m. - 10 a.m.
(i)			
(ii)			
(iii)			
(iv)			

3. WHEN DID NOISE FIRST BECOME A PROBLEM? _____

_____

_____

4. HAVE YOU CONTACTED NOISE PRODUCER DIRECTLY? YES ☐ NO ☐

IF YES: WAS REACTION CO-OPERATIVE? ☐ CONCERNED? ☐

HOSTILE? ☐

5. OTHER COMMENTS: _____

_____

_____

Investigating Officer(s): 1. _____

2. _____

Figure II.3.D.1

Noise-Producer's Interview Report:

The investigator during the course of the preliminary investigation will also interview the noise-producer. The investigator should always enter a plant or premises through the main entrance, and identify himself with his identity card, and ask for a senior company official. The investigator should then state that the purpose of his visit is to investigate a noise complaint, and that he is trying to locate the noise source.

To provide some guidance in the questioning of the noise producer, the NOISE PRODUCER INTERVIEW FORM (shown in Figure II.3.D.2) should be completed.

It is also useful to obtain all the relevant data about the noise source if it can be identified during the visit.

It may sometimes be advisable not to warn the suspected noise producer of the first visit made to observe the situation. A surprise visit may indicate that a laxness in procedures is a contributing factor to the noise problem; and may prevent a quick, but temporary, rectification of the noise problem prior to the investigator's arrival.

Investigator's Observations Report:

After the investigator has interviewed the complainant and the noise producer, he should make a subjective assessment of the noise and report his findings using the INVESTIGATOR'S OBSERVATIONS FORM (Figure II.3.D.3).

The subjective assessment will include what in the investigator's opinion is causing the noise and whether there is a simple solution to the problem.

A map or diagram showing land usage (and zoning if available), together with measurement locations, should be added together with any photographs or sketches of the source that the investigator feels is necessary. A suggested form for this is presented in the Figure II.3.D.4. Relative location of complainant and the noise producer must be clearly indicated on this diagram

INVESTIGATION NUMBER

Date: _____

INVESTIGATION REPORT
NOISE PRODUCER INTERVIEW

PREMISES KNOWN AS: _____ PHONE _____

ADDRESS: _____

_____

CONTACT NAME: _____ TITLE _____

1. IS THE NOISE PRODUCER AWARE THAT HE IS CAUSING A NOISE PROBLEM? YES ☐ NO ☐

   IF YES, DOES HE KNOW THE NOISE SOURCE? YES ☐ NO ☐

2. DESCRIBE THE NOISE SOURCE. IF AN AIR-CONDITIONER IN A RESIDENCE, WHAT IS THE OUTPUT, MAKE AND MODEL?

   _____

   _____

3. WHAT ARE HOURS OF OPERATION OF NOISE SOURCE(S)? (THIS SHOULD CONFIRM OR DENY THE COMPLAINT HOURS). ALSO NOTE ANY CYCLES OF OPERATION.

   _____

   _____

   _____

4. CAN EQUIPMENT BE SWITCHED ON AND OFF FOR MEASUREMENTS? YES ☐ NO ☐

   IF YES, WHEN? _____

5. CAN EQUIPMENT BE SWITCHED OFF OR REDUCED IN POWER AS A WAY OF LESSENING NOISE? (e.g. AT NIGHT) YES ☐ NO ☐

   IF YES, WHEN? AND DOES INVESTIGATOR FEEL THIS MAY HELP?

   _____

6. HAS THE NOISE PRODUCER ANY FUTURE PLANS THAT MAY ABATE THIS PROBLEM? YES ☐ NO ☐

   IF YES, GIVE DETAILS INCLUDING DATES _____

7. WAS NOISE SOURCE OPERATING AT TIME OF VISIT? YES ☐ NO ☐

Investigation Officer(s): 1. _____

2. _____

Figure II.3.D.2

INVESTIGATION NUMBER

[ ]

Date: _____

INVESTIGATION REPORT
INVESTIGATOR'S OBSERVATIONS

1. DOES NOISE HAVE AN AUDIBLE TONAL QUALITY? YES [ ] NO [ ]
   IF YES, DESCRIBE _____

2. DOES THERE SEEM TO BE A BEAT? YES [ ] NO [ ]

3. DOES THERE SEEM TO BE AN IMPACT NOISE? YES [ ] NO [ ]
   IF YES, DESCRIBE _____

4. DOES THERE SEEM TO BE A VIBRATION? YES [ ] NO [ ]
   IF YES, DESCRIBE _____

5. WHAT APPEARS TO BE CAUSING THE NOISE? _____

   _____

6. CAN THE PROBLEM BE VERY OBVIOUSLY ABATED? YES [ ] NO [ ]
   IF YES, HOW? _____

   _____

7. WAS THE NOISE PRODUCER'S ATTENTION DRAWN TO THE OBVIOUS REMEDY? YES [ ] NO [ ]

8. DID THE NOISE PRODUCER SEEM WILLING TO CO-OPERATE IN ABATING THE PROBLEM? YES [ ] NO [ ]
   IF YES, HOW? _____

   _____

   _____

9. IS THE NOISE EXCESSIVE IN THE INVESTIGATOR'S OPINION? YES [ ] NO [ ]
   ANY SPECIAL REASONS: _____

   _____

10. CIRCLE CATEGORY OF PREDOMINANT NOISE: PRIT PUBT SOEJ
    HVAC INDP COMP CDOM RECV REDL OTHR

Investigation Officer(s): 1. _____

2. _____

Figure II.3.D.3

SKETCH OF MEASUREMENT LOCATION(S)

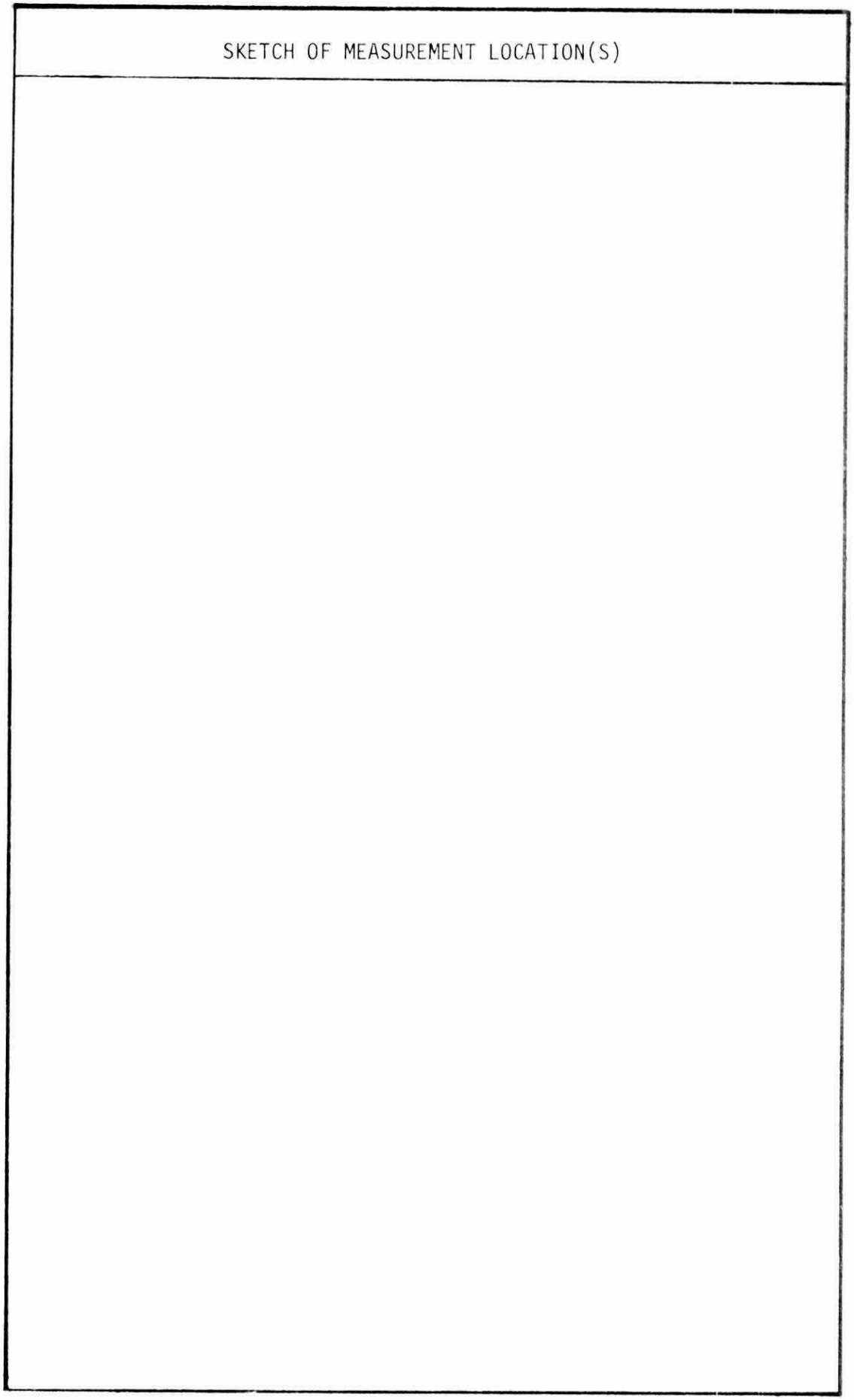


Figure II.3.D.4

II.3.D.3 FORMS TO RECORD FIELD MEASUREMENT DATA:

The measurement data collected in the field is documented on the forms (shown in Figures II.3.D.5 and II.3.D.6). Measurement of full octave band and different weighting networks are recorded on the form of Figure II.3.D.5. The form shown in Figure II.3.D.6 is used for one-third octave band measurements only, and is usually employed in a subsequent investigation of a noise complaint. The important parts of these record sheets are covered below.

Instrumentation:

It is recommended that the serial numbers of equipment be noted on each investigation as a matter of good practice although they may only be required when legal action is considered or in the case of suspected instrument malfunction.

Weather Conditions:

The weather conditions at the time of the SOUND LEVEL MEASUREMENTS should be noted. Under the heading "PRECIP." note"none/rain/snow"as applicable. Local meterological office can provide most of this data. Outdoor measurements are not usually conducted when wind speed exceeds 10-12 M.P.H. Measurements are also avoided when relative humidity is high (in the range of 90%).

Noise Characteristics:

Indicate on the data sheet if the noise is tonal; impulsive or has a beat.

Intermittent:

The length of time the noise is 'OBSERVED' in a 60 minute period is noted under one of the three headings of less than or equal to 5 minutes, between 5 and 15 minutes or more than 15 minutes.

Frequency graph of Figure II.3.D.7. is used to plot both full octave and one-third actave band measurements.

SOUND MEASUREMENTS DATA SHEET (FULL OCTAVE BANDS AND DIFFERENT WEIGHTING NETWORKS)

DATE | INVEST NO.

INSTRUMENTATION			
	Make	Type	Ser. No.
Sound Level meter			
Microphone			
Octave analyser			
Calibrator			

MEASUREMENT CONDITIONS					
Time					
Wind Speed					
Wind Direction					
Temp.					
Precip.					
R.H. %					
Battery					
Cal. Before					
Cal. After					

INVESTIGATORS 1.
2.

NOISE CHARACTERISTIC

TONAL		IMPULSE		BEAT	
Yes	No	Yes	No	Yes	No

INTERMITTENT: Observed duration in any 60 minute period

≤5 mins.	>5-≤15 mins.	>15 mins.

CIRCLE THE OCTAVE BAND WHERE BEAT OCCURS

No.	MEASUREMENT POSITION	Posn on diag.	Meter Response F/S	Time	dBA	dBB	dBC	dB Lin.	dB LEVEL - O.B. CENTRE FREQUENCY (Hz)										COMMENTS
									31.5	63	125	250	500	1K	2K	4K	8K	16K	
1																			
2																			
3																			
4																			
5																			
6																			

SOUND LEVEL MEASUREMENTS - (ONE-THIRD OCTAVE BANDS)

DATE		INVEST NO.	

INVESTIGATORS 1.
2.

INSTRUMENTATION			
	Make	Type	Ser. No.
Sound level meter			
Microphone			
1/3 octave analyser			
Calibrator			

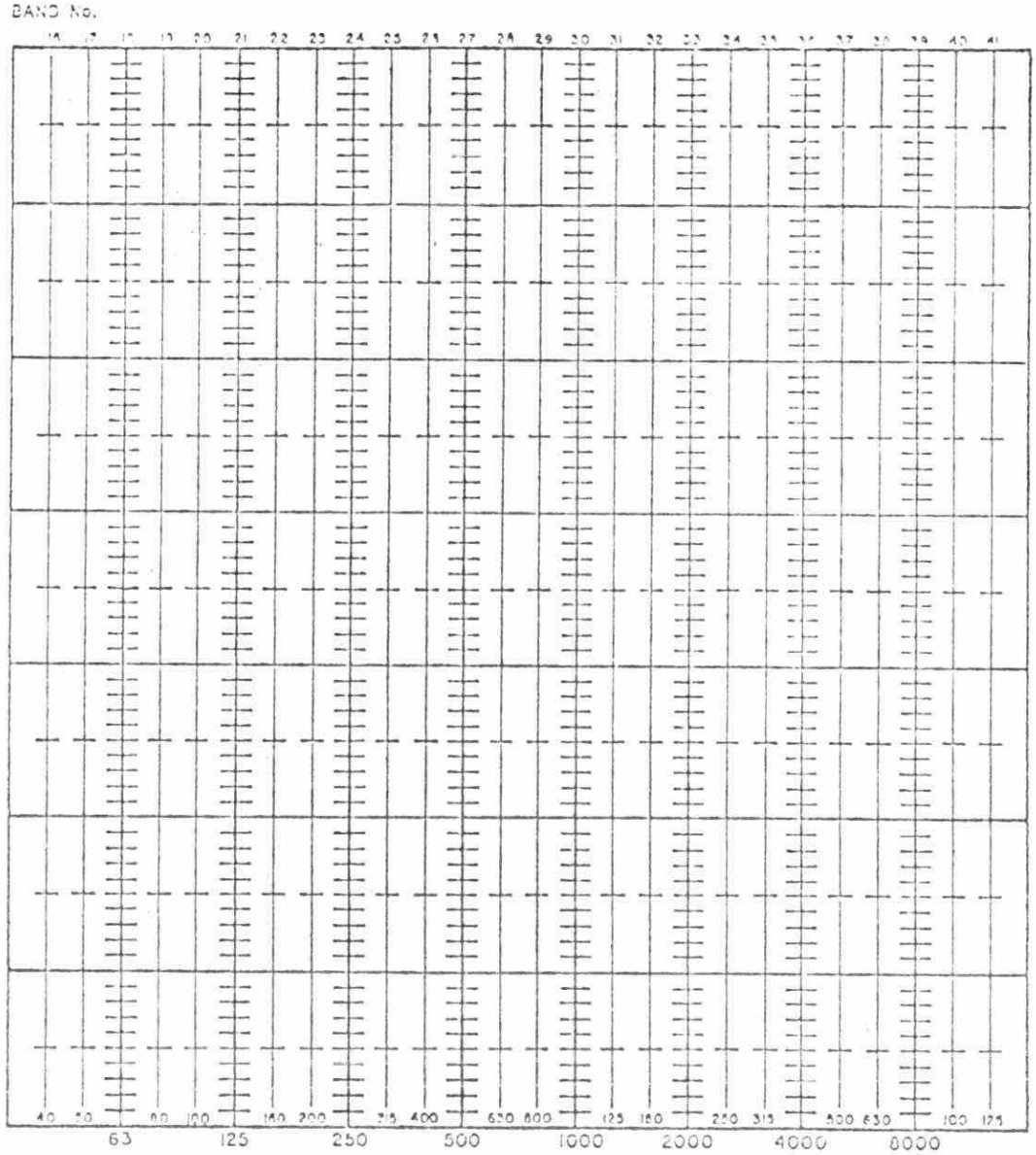
MEASUREMENT CONDITIONS					
Time					
Wind Speed					
Wind Direction					
Temp.					
Precip.					
R.H. %					
Battery					
Cal.	Before				
	After				

1/3 O.B. in which tone occurs is ▼					
Hz.					
dB					
	adjacent bands		tonal band		adjacent bands

No.	MEASUREMENT POSITION	Posn on diag	Meter Response F/S	Time	dBA	dBB	dBC	dB Lin.	dB LEVEL - 1/3 O.B. CENTRE FREQUENCY (Hz)												COMMENTS
									25	31.5	40	50	63	80	100	125	160	200	250		
1																					
2																					
3																					

	dB LEVEL - 1/3 O.B. CENTRE FREQUENCY (Hz)																			
	315	400	500	630	800	1K	1.25K	1.6K	2K	2.5K	3.15K	4K	5K	6.3K	8K	10K	12.5K	16K	20K	
1																				
2																				
3																				

Figure II.3.D.6



FREQUENCY IN HERTZ

Figure II.3.D.7

LEGEND

GRAPH TITLE

GRAPH NUMBER

DATE

II.3.D.4. ACOUSTIC INTRUSION FLOW CHART:

Having done the interviews and the field measurements, the next step in noise investigation procedure is to determine whether the noise situation involves an acoustic intrusion. This procedure is outlined in this sub-section.

Presented below is the definition of acoustic intrusion, followed by various criteria used to establish whether an acoustic intrusion exists for different types of noise sources covered in the Municipal Noise Control By-law. The model by-law listing all different noise sources is quoted below in full, grouped together with the corresponding acoustic intrusion criteria.

To use this scheme, simply identify the source of the noise complaint with one of the given noise source categories and then follow the appropriate flow chart.

* Acoustic Intrusion

The sound caused by each of the following acts is an acoustic intrusion if clearly audible at a point of reception.

Noise Source Category 1

The acoustic intrusion due to the sources in this category applies to areas of municipality as specified in Table 8.

Noise Source Category 1		Quiet Zone	Residential Land Use	All other Areas
1(a)	Auditory signalling devices	At any time	A - B & C	A - B
1(b)	Loudspeakers	At any time	X - Y & C	
1(c)	Street sales	At any time	X - Y & C	
1(d)	Loading and delivery	X - Y	X - Y & C	
1(e)	Construction Equipment	A - B	A - B & C	
1(f)	Explosives	At any time	X - Y & C	A - B
1(g)	Firearms	At any time	X - Y & C	A - B
1(h)	Powered models	At any time	X - Y & C	A - B
1(i)	Idling of locomotives and rolling stock	At any time	A - B & C	
1(j)	Car washes	At any time	A - B & C	
1(k)	Off road conveyences	At any time	A - B & C	
1(l)	People Noise	At any time	A - B & C	
1(m)	Tools & equipment	At any time	A - B & C	
1(n)	Musical instruments	At any time	A - B & C	
1(o)	Venting	At any time	X - Y & C	
1(p)	Repairs and testing	At any time	X - Y & C	A - B

NOTE: 1) A suggested restricted time may be - A-B = 22:00 hrs One Day, 07:00 hrs Day

2) " " " " " " X-Y = 17:00 " " " , 10:00 " "

3) " " " " " " C = all day Sundays and statutory holidays

Table 8 : Time Restrictions for Noise Source Category 1

1 (a) Auditory Signalling Devices

The operation of any auditory signalling device, including, but not limited to, the ringing of bells or gongs, the blowing of horns or sirens or whistles, or the production, reproduction or amplification of any similar sounds by electronic means, unless required or specifically permitted by law, or not in excess of the maximum permissible sound levels specified in category 9.

(b) Loudspeakers

The operation of any electronic device or group of connected electronic devices, incorporating one or more loudspeakers or other electro-mechanical transducers, and intended for the production, reproduction or amplification of sound, unless not in excess of the maximum permissible sound levels specified in category 9.

(c) Street Sales

Selling or advertising anything by shouting, outcry or amplified sound.

(d) Loading and Deliveries

Loading, unloading, delivering, packing, unpacking, or otherwise handling any containers, products, materials, or refuse, whatsoever, when done for profit.

(e) Construction

The operation of any construction equipment.

(f) Explosives

The setting off of fire-works or explosive devices.

(g) Firearms

The discharge of firearms.

(h) Powered Models

The operation of a combustion engine which,

(i) is, or

(ii) is used in, or

(iii) is intended for use in,

a toy or model or replica of a larger device, which model or replica has no function other than amusement, and which is not a conveyance.

(i) Idling of Locomotives and Rolling Stock

The operation of any powered rail car, including but not limited to refrigeration cars, locomotives or self-propelled passenger cars, while stationary on property not owned or controlled by a railway governed by the Canada Railways Act.

(j) Car Washes

The operation of any commercial car wash or car wash system or any part thereof.

(k) Off-Road Conveyances

The operation of any motorized conveyance other than on a highway.

(l) People Noise

Yelling, shouting, hooting, whistling, singing and the holding of parades, processions or gatherings.

(m) Tools and Equipment

The use or operation of any device, including any powered or nonpowered tool, or item of machinery or equipment, other than a device to which category 6 applies, by an inhabitant or his agent for the domestic purposes of such inhabitant, unless not in excess of the maximum permissible sound levels specified in category 9.

(n) Musical Instruments

The playing of any band and of any musical instrument, except by a military band attached to any regular corps of the militia of Canada, when on duty, under the command of its regular officer.

(o) Venting

The venting, release or pressure relief of air, steam or other gaseous material, product or compound from any autoclave, boiler, pressure vessel, pipe, valve, machine, device or system, unless not in excess of the maximum permissible sound levels specified in category 9.

(p) Repairs and Testing

Repairing, rebuilding, modifying or testing any motorized conveyance or motor or engine or device powered by a motor or combustion engine.

The flow chart to determine an acoustic intrusion of sources in category 1 is given in Figure II.3.D.8.

Applies to Sources Banned When Audible at Specified Times and Zones

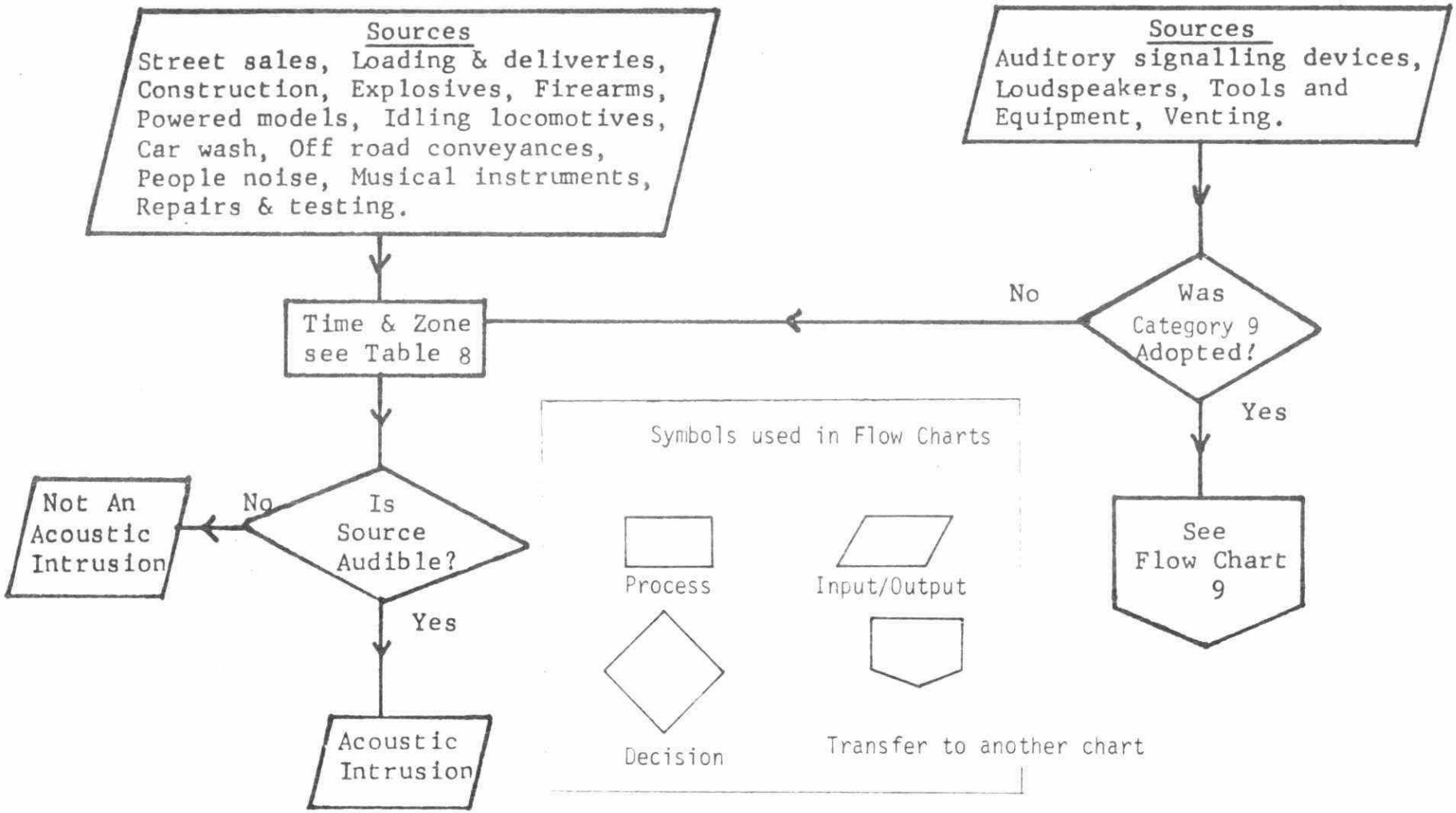


Figure II.3.D.8. Acoustic Intrusion Flow Chart of Noise Source Category 1

Noise Source Category 2

2(a) Animals

The sound made by any animal, including any bird, if such sound persists for a period of time in excess of one half hour between 08:00 and 22:00 hours of one day, or persists for a period of time in excess of 15 minutes between 22:00 hours of one day and 08:00 hours of the following day.

(b) Construction Sound Control Devices

The sound produced by the operation of any construction equipment when operated without sound-control devices or with sound-control devices less effective in reducing the level of sound emitted than the best sound-control devices available at the time of the first purchase of the equipment, as specified by the original equipment manufacturer, or as designated in Publication NPC 113 as an acceptable substitute.

(c) Racing

The sound produced by the operation of any motorized-conveyance in a racing event, unless the conduct of the racing event is regulated by law.

(d) Tire Squeal

The squealing of tires on a motor vehicle.

(e) Vehicle Braking

The squealing or screeching sound produced by the operation of the brake mechanism of a motor vehicle on a highway.

(f) Muffler

The sound produced by the operation of any combustion engine, except one to which clause (h) of category 1 applies, without an effective muffling device in good working order and in constant operation.

(g) Miscellaneous Vehicular Noise

The banging, clanging, rattling or other like sound coming from a vehicle or the load on a vehicle or the trailer of a vehicle or the load on such trailer, unless operated on road surfaces which are not in good repair.

(h) Idling of Motor Vehicles

The sound produced by the operation of any engine or motor in or on any motor vehicle or attached auxiliary equipment for a continuous period exceeding five minutes, while such vehicle is stationary in a residential or commercial area as designated in the zoning by-law No._____ unless:

(i) the vehicle is in an enclosed structure constructed so as to effectively prevent excessive noise emission; or

(ii) the original equipment manufacturer specifically recommends a longer idling period for normal and efficient operation of the motor vehicle, in which case such recommended period shall not be exceeded; or

(iii) operation of such engine or motor is essential to a basic function of the vehicle or equipment, including, but not limited to, operation of ready-mixed concrete trucks, lift platforms or refuse compactors and heat exchange systems; or

(iv) weather conditions justify the use of heating or refrigerating systems powered by the motor or engine for the safety and welfare of the operator or passengers; or

(v) prevailing low temperatures make longer idling periods necessary, immediately after starting the motor or engine; or

(vi) the idling is for the purpose of cleaning and flushing the radiator and associated circulation system for seasonal change of antifreeze, cleaning of the fuel system, carburetor or the like, when such work is performed other than for profit.

The acoustic intrusion flow chart for noise source category 2 is given in Figure II.3.D.9.

Applies to Sources Prohibited Outright

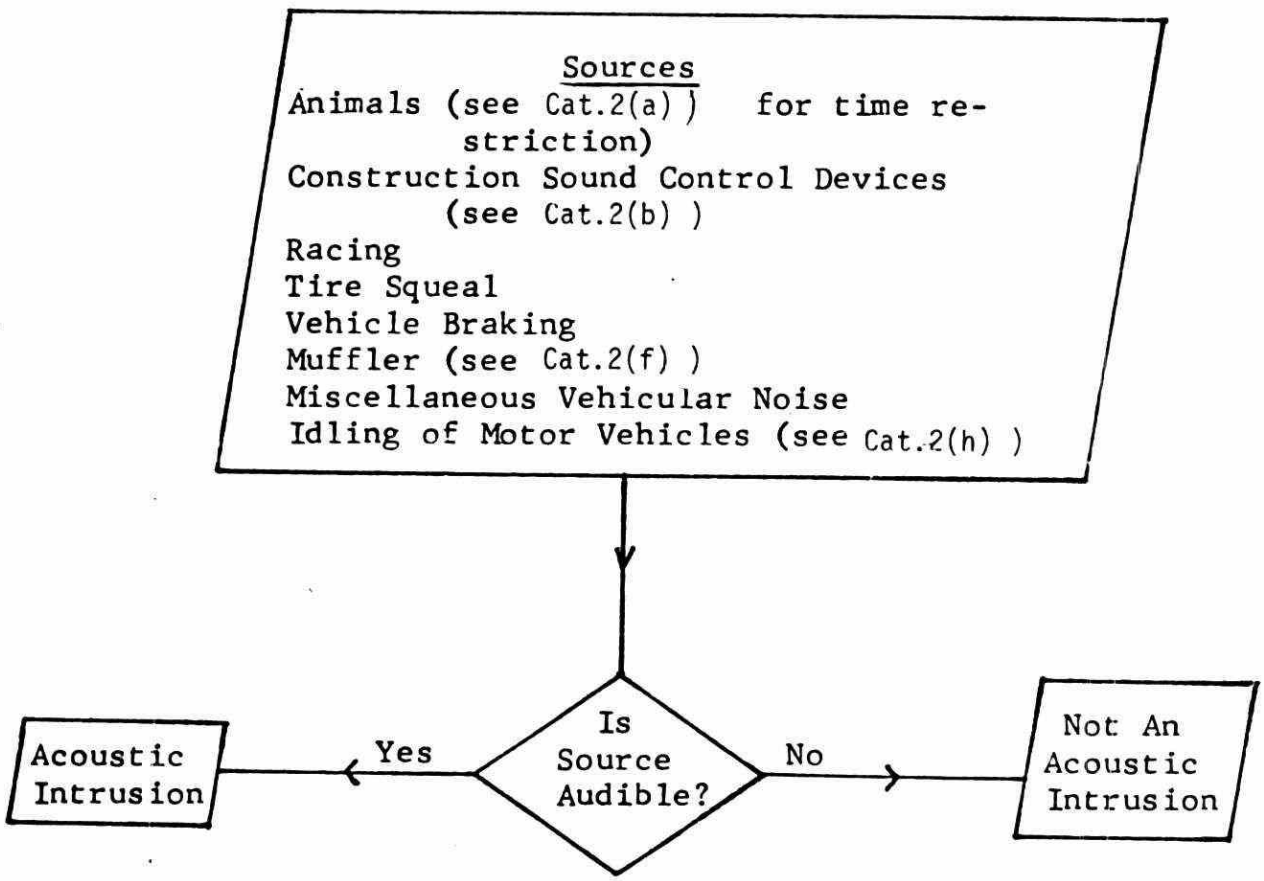


Figure II.3.D.9: Acoustic Intrusion Flow Chart of Noise Source Category 2

Noise Source Category 3

3 Excitation

The sound or vibration produced by the use or operation of any machine, device, vessel, process or thing is an acoustic intrusion, if such sound or vibration causes any other machine, device, vessel or thing to vibrate in such a way that it produces sound which is an acoustic intrusion (flow chart of Figure II.3.D.10).

Noise Source Category 4

4 Construction Equipment

The sound produced by the operation of any construction equipment at a construction site any part of which is located within 600 metres of premises which are normally used for residential, commercial or industrial pruposes or for the keeping of animals, or within 600 metres of any part of a Quiet Zone as specified in Table 8 , is an acoustic intrusion if it exceeds the applicable sound levels set out in Publication NPC 115 (refer to the Section II.3.A.) for the specific type of equipment, when tested in accordance with the procedures indicated therein. The flow chart is given in Figure II.3.D.11.

Noise Source Category 5

5 Air Conditioners

The sound produced by the operation of residential air conditioning equipment, including, but not limited to, through-the-wall, split central, unitary central, and heat-pump installations, is an acoustic intrusion if it produces a sound level which exceeds the limit set out in Publication NPC 116 (refer to the Section II.3.A.) when measured at a point of reception. The flow chart is given in Figure II.3.D.12.

Noise Source Category 6

6 Domestic Power Tools

The sound produced by the use or operation of any device, including any tool or item of machinery or equipment, which device is powered by an electric motor or an internal combustion engine, by an inhabitant, or his agent, for the domestic purposes of such inhabitant, is an acoustic intrusion if such device produces a sound level which exceeds the limit applicable to that type of device, set out in Publication NPC 117, when measured at a point of reception. The flow chart is given in Figure II.3.D.12.

Applies to One Source Excited by Another

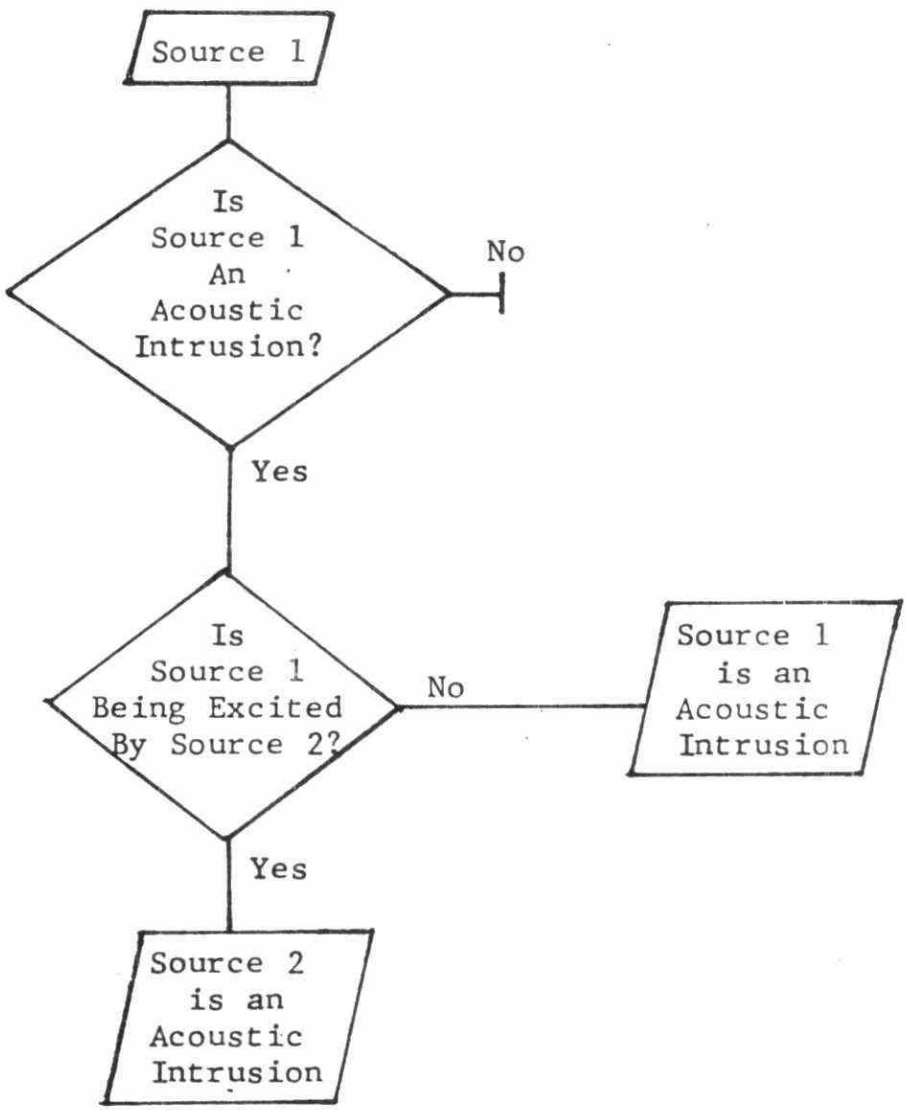


Figure II.3.D.10: Acoustic Intrusion Flow Chart of Noise Source Category 3

Applies to Construction Equipment

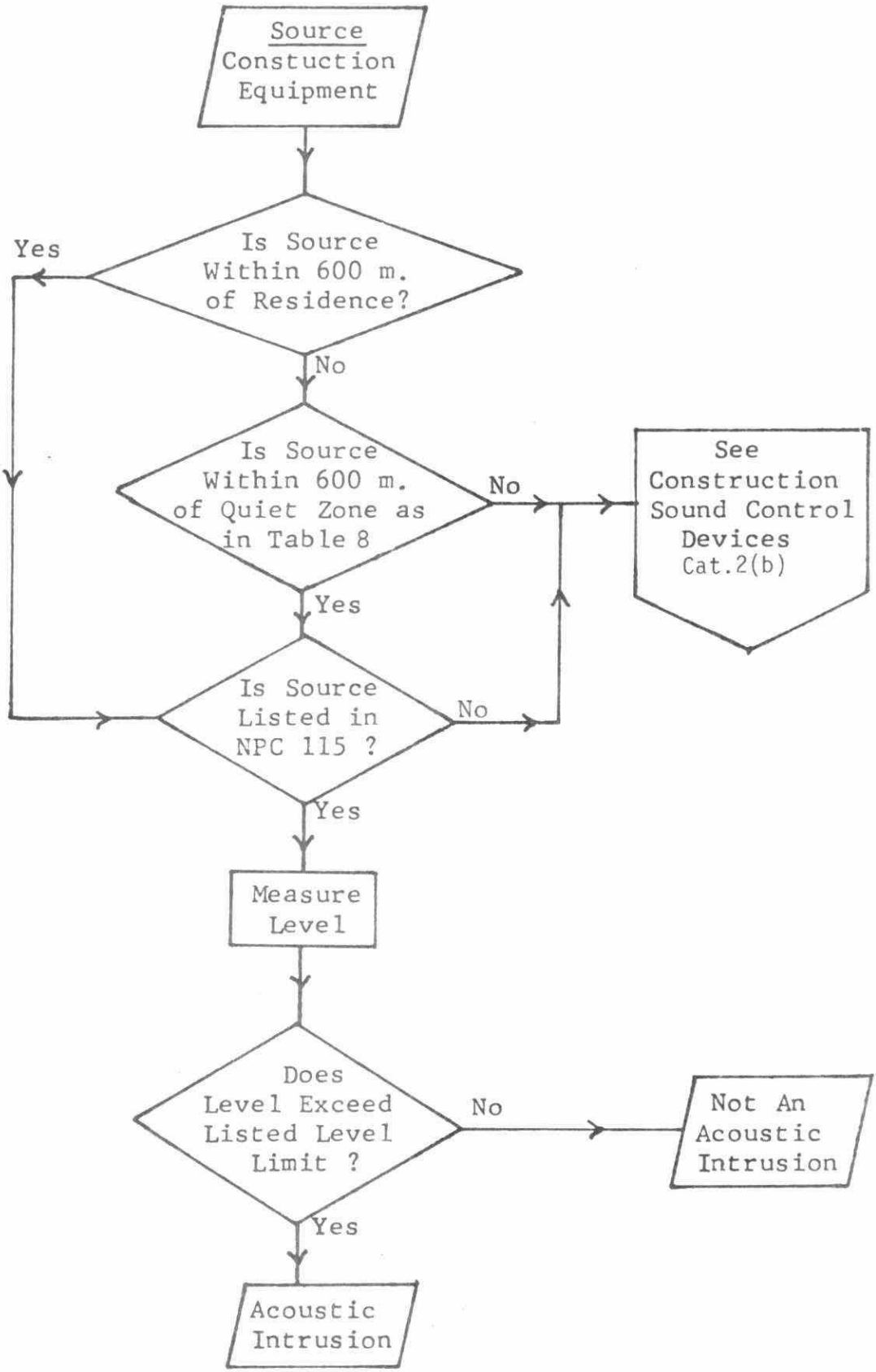


Figure II.3.D.11: Acoustic Intrusion Flow Chart of Noise Source Category 4

Noise Source Category 7

7 Motorized Conveyances

The sound produced by any motorized conveyance is an acoustic intrusion if the sound level produced by the operation of the conveyance, or of the motor or engine of the conveyance, when subjected to any test shown in Publication NPC 118 as applicable to that type of conveyance or motor or engine, exceeds the sound level indicated therein. The flow chart is given in Figure II.3.D.12.

Noise Source Category 8

8(1) Blasting, Overpressure

The concussion (air blast) produced by a blasting operation is an acoustic intrusion if the peak overpressure level resulting from such operation, when measured as prescribed in the sub-section II.3.A.2.(C), exceeds the limit specified in Publication NPC 119.

8(2) Blasting, Ground Vibration

The vibration produced by a blasting operation is a vibratory intrusion if the ground vibration velocity exceeds the limit specified in Publication NPC 119 when measured at any point as prescribed in the sub-section II.3.A.2.(C). The flow chart is given in Figure II.3.D.12.

Noise Source Category 9

9 Sound Level Limits

The sound from a source is an acoustic intrusion if, when measured at a point of reception, the sound level of the sound exceeds the maximum permissible level set out in Table 9, adjusted in accordance with Publication NPC 120, indicated as applicable to that part of the Municipality in which and the time of day at which the sound is measured.

Applies to **Air Conditioners, Domestic Power Tools,** Motorized Conveyances, Blasting and Ground Vibration, Vibration.

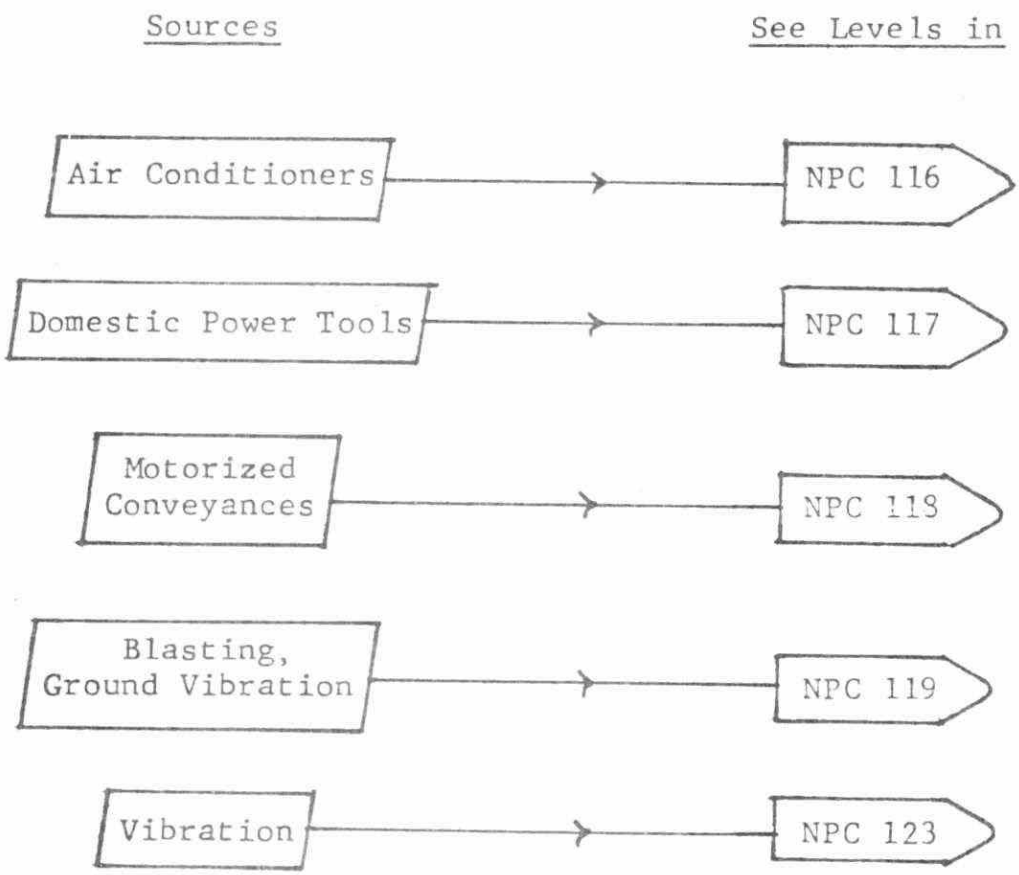


Figure II.3.D.12: Flow Chart of Noise Source Categories 5,6,7,8, & 12

RESIDENTIAL AREA DESCRIPTION	SOUND LEVEL LIMIT dBA		
	"Night"	"Evening"	"Day"
Residences in sparsely populated area; distant from population centres; environment dominated by natural sounds (people and/or animals).	40	45	45
Semi-rural small community; several miles from major throughway; no industrial or commercial activity.	45	50	50
Small or suburban community; no major through streets; sound environment dominated by distant traffic; recreational activity; occasional train, boat or light aircraft.	48	52	55
Suburban or urban residential community; close to transportation corridor; some commercial or light industrial activity; close to recreational areas; some intrusions due to light aircraft.	50	55	60
Residential community adjacent to busy streets, related to commercial activity, or large industry.	55	60	65

NIGHT: 23:00 - 07:00 hours, all day Sunday and statutory holidays.

EVENING: 19:00 - 23:00 hours

DAY: 07:00 - 19:00 hours

Table 9 : Sound Level Limits

9(3) Impulse Sound Level Limits

The sound from a source is an acoustic intrusion if it is of an impulse nature and, when measured at a point of reception, the impulse sound level of the sound exceeds the maximum permissible level set out in Publication NPC 124 indicated as applicable to the time of day at which the sound is measured. Refer to Figure II.3.D.13. for the flow chart.

9(4) Exceptions

This section does not apply to sound from sources mentioned in sections 4, 5, 6, 7, 8 inclusive.

Noise Sound Category 10

10 Multiple Sources

The sound from a source is an acoustic intrusion if:

(i) the resultant sound from the source in question and one or more additional sources, when measured at a point of reception common to all of the said sources, would be an acoustic intrusion under the provisions of category 9 if it were applicable, and

(ii) the sound from no one of the said sources is an acoustic intrusion under the provisions of category 9 and

(iii) the person in apparent charge or control of the source in question failed to forthwith reduce the level of sound coming from the source when he and those persons in apparent charge or control of the said sources of sound were all asked to do so by the Noise Control Officer.

Noise Sound Category 11

11 Sound Within Buildings

The sound audible within a dwelling unit caused by sound or vibration transmitted through the ground or the structure of a building or both, is an acoustic intrusion if the sound pressure level of such sound in any octave band exceeds the greater of,

(i) the applicable values listed in Publication NPC 121, and

(ii) the normal sound pressure levels prevailing within the dwelling unit.

Noise Sound Category 12

12 Vibration

The vibration produced by the use or operation of any machine, device, vessel, process or thing is a vibratory intrusion if such vibration exceeds the limits set out in Publication NPC 123 when measured at a point of reception.

Applies to Sources not specifically listed, that are steady, intermittent, or random.

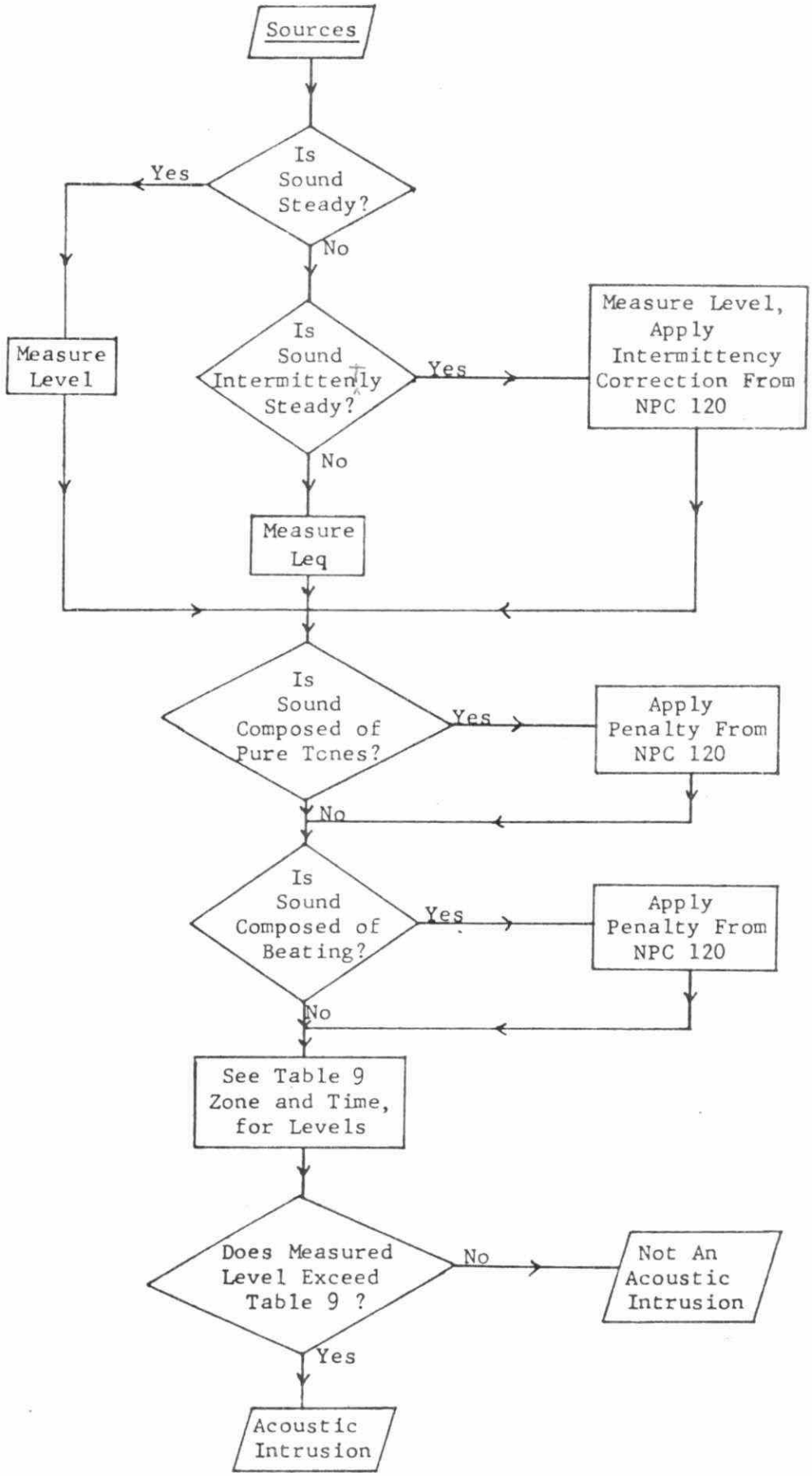


Figure II.3.D.13: Acoustic Intrusion Flow Chart of Noise Source Category 9 .

II.3.D.5. MAINTAINING COMPLAINT STATISTICS:

The main purpose of keeping a record of noise complaint statistics is to provide basic information which can be analyzed in a number of ways to answer various questions thought to be of interest either at the time the statistics are gathered or at a later date.

Some examples of useful analysis of noise complaints are:

- the number of noise complaints received per year or per month.
- the number of complaints in each noise source category.
- the geographical areas in which the complaints most occur.
- the average length of time taken to investigate a complaint.
- the number of complex and less complex investigations.
- the number of people benefiting from noise reduction.

The main purpose of most complaint statistics analysis is to provide information which will be of use in planning manpower and instrument allocation in local noise control program. Consider the three histograms of Figure II.3.D.8 as an illustration. *HVAC and non-HVAC complaints are shown for each month in a municipality, as well as mean daily maximum outdoor temperature. Most of HVAC complaints occur during the three hottest months -- June, July and August. Non-HVAC complaints are less dependent on weather conditions although a peak effect is also noted during the same three months. The graphs clearly indicate an increased workload in summer months and hence provide a tool in planning of resources in noise control activity.

The statistics, when studied, will probably reveal ways in which the municipality's procedures, people and equipment can be better directed.

The information gained from the analysis when passed on to the Ministry of the Environment by the MUNICIPALITY

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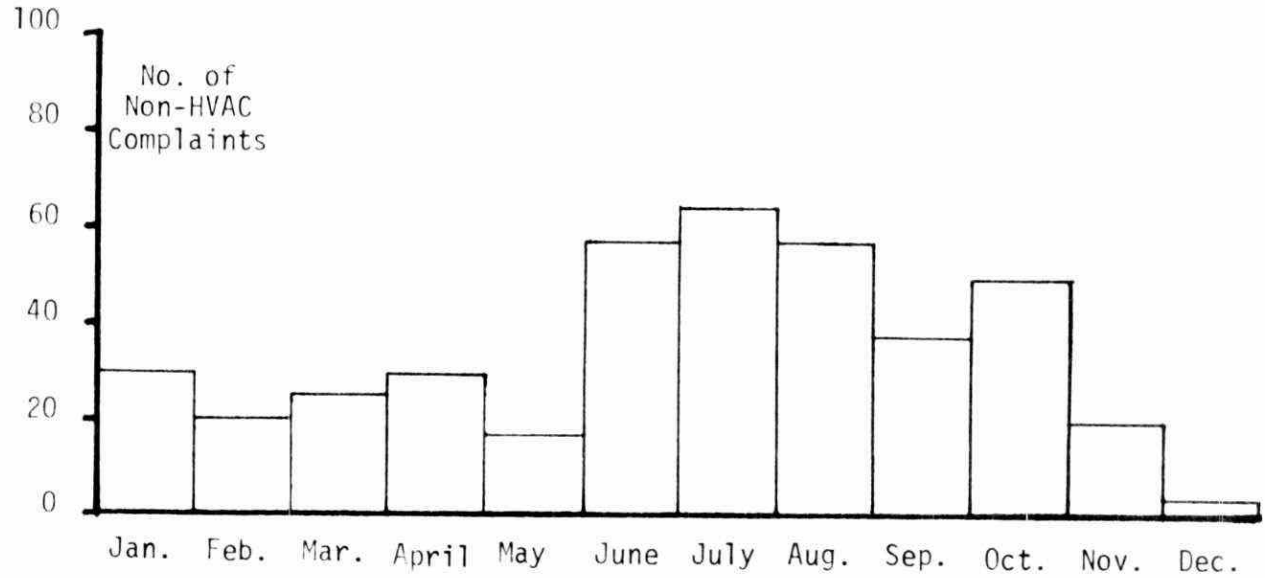
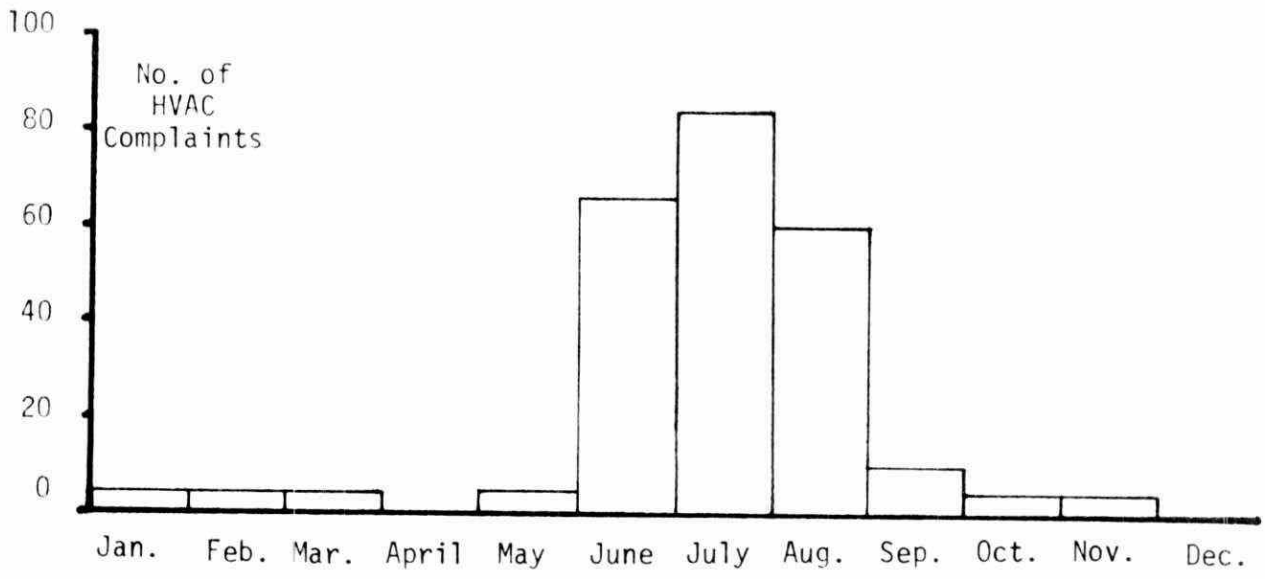
*HVAC = Heating, Ventilating, and Air Conditioning.





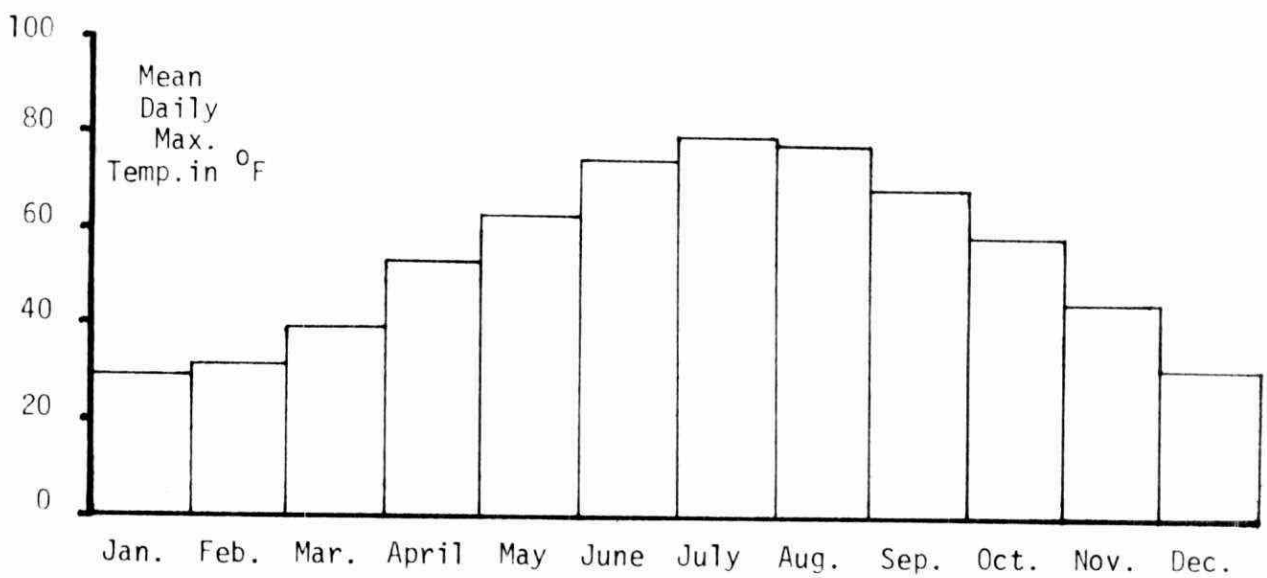


Figure II.3.D.14: 1974 Noise Complaint Statistics of a Typical Municipality

(as covered in Publication NPC 111 - RECORD KEEPING AND ANNUAL RETURNS) will provide an indication of the effectiveness of the noise control activities being carried out by the municipalities.

The returns will allow problem areas to be identified and would indicate where further action, such as legislative activity directed at the manufacturing level, etc., is required.

OBJECTIVES:

Trainee will be able to:

1. Calibrate and prepare an L_{eq} measurement system;
2. Use an L_{eq} measurement system to obtain several L_{eq} values for different time intervals from a pre-recorded continuous time varying noise sample, and be able to explain differences in the L_{eq} values obtained;
3. Obtain an L_{eq} measurement for an intermittent noise sample and use the trade-off level with time to convert the L_{eq} level obtained to a different time interval;
4. Understand the difference between an L_{eq} of a short sample of continuous noise and an L_{eq} of an intermittent noise obtained when the noise is on.

II.4.A.& B.1 CALIBRATOR AND PREPARATION OF AN L_{eq} MEASUREMENT SYSTEM

1. Description of an L_{eq} Measurement System:

Shown in Figure II.4.A.& B.1 is an L_{eq} measuring system.

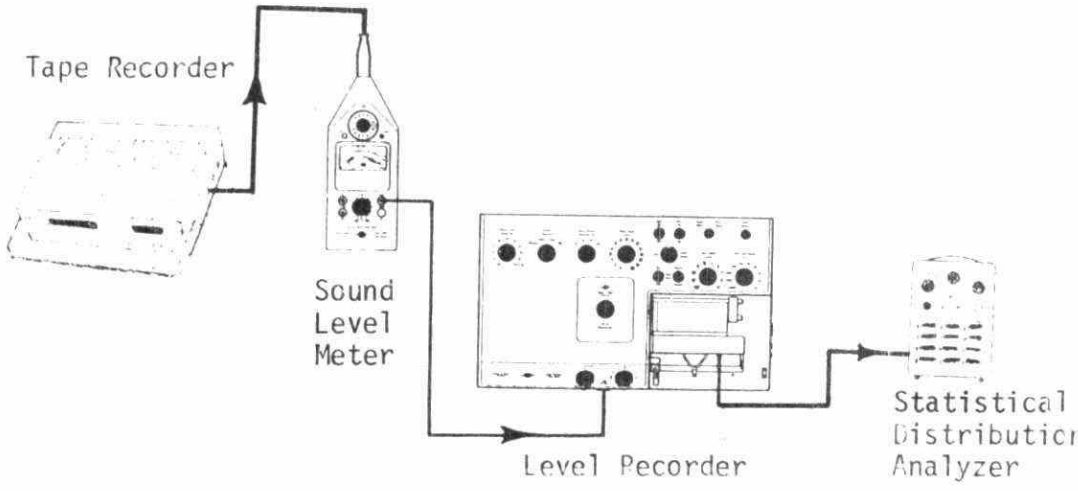


Figure II.4.A.& B.1: L_{eq} Measurement System.

Note: The strip level recorder and statistical distribution analyzer are described in detail later in a subsequent training course.

The pre-recorded noise sample is played back using a tape recorder, and passed to a sound-level meter, the microphone of which has been replaced by an adaptor. The sound level meter is used to A-weight and amplify the tape-recorded sample. From the sound-level meter the signal is passed to a level recorder, the pen of which traces out the variation of the noise-level on a roll of calibrated paper. Mounted on the pen is a slider which moves over a set of twelve electrical contacts. Each time the pen passes a contact a pulse is passed to a statistical distribution analyzer which counts the number of times the pen passes each of the twelve

contacts. As the contacts correspond to a sound level interval of 5dB, this process is equivalent to splitting the time varying sound into 5dB wide level bands. The statistical distribution analyzer will indicate how long the pen remained in each 5dB band.

2. Interpretation of Results from the Statistical Distribution Analyzer:

The statistical distribution analyzer has 13 counters in all. One counter registers the total count, from which the time of the measurement can easily be derived. The first of the remaining counters counts the time that the pen was off the bottom of the recording paper. This count should ideally be zero. The twelfth counter counts the time that the pen was off the top of the recorder paper and again should ideally be zero. The remaining 10 counters count the time the pen was in each of ten 5dB wide bands which make up the 50dB total range of the level recorder paper.

3. Initial Settings for the System:

The system should be fully connected and set-up for the test. However, the following settings should be checked. The settings should not be altered unless so instructed in the text of the workshop.

Uher 4200 Stereo Tape Recorder

SPEED	"1 7/8 i.p.s." - 2nd bar from right
CHANNEL SELECTOR	"Stereo" - both buttons in

B & K 2203 Precision Sound Level Meter

OUTPUT ATTENUATOR	"Fully Clockwise"
WEIGHTING KNOB	A "Fast"

B & K 2305 Level Recorder

POTENTIOMETER RANGE	"50 dB"
RECTIFIER RESPONSE	"RMS"
LOWER LIMITED FREQUENCY	"20Hz"
WRITING SPEED	"100 mm/s"
POWER	"On"

MOTOR	"On"
PAPER SPEED	"3mm/s"
INPUT ATTENUATOR	"0dB"

B & K 4420 Statistical Distribution Analyzer:

POWER	"On"
FUNCTION SELECTOR	"Distribution 2305"
PERIOD SELECTOR	"0.1 sec"
PULSE GENERATOR	"Off"

4. Calibration:

(a) A calibration tone of 94 dBA at 1000 Hz is recorded at the beginning of the tape for analysis. To find this tone press the START key of the Uher and with the VOLUME knob approximately mid-range find the beginning of the calibration signal. Press the PAUSE key on the Uher.

(b) Pull the WEIGHTING KNOB on the sound level meter "On" and lift the PAUSE key on the Uher. Adjust the INPUT ATTENUATOR on the sound level meter to give a deflection in the upper 10 dB of the scale. Using a small screwdriver adjust the"ADJ" screw to give a meter scale reading of 4 dB.

(c) Push and turn clockwise the "SINGLE CHART / CONT. RECORD" button on the level recorder and lower the pen. Adjust the INPUT POTENTIOMETER to give a pen deflection of 94 dB (i.e. on the sixth line down from the uppermost line of the paper). The level recorder paper (and hence the distribution analyzer) is now calibrated so that the bottom line of the paper corresponds to 50 dBA and the uppermost line to 100 dBA.

(d) Release the "SINGLE CHART / CONT RECORD" button on the level recorder by turning anticlockwise, raise the pen and press the PAUSE key on the Uher. The INPUT POTENTIOMETER knob on the level recorder should not be altered for the rest of the workshop unless otherwise instructed.

II.4.A.& B.2. L_{eq} ANALYSIS OF A TAPED SAMPLE FOR VARYING TIME DURATIONS

The first recording on the tape is a sample from a noise source which is unsteady but is in continuous operation during the day. This sample will be analyzed for 10 sec, 1 min, and 5 minutes.

(a) Set the PERIOD COUNTER on the distribution analyzer to 100. As the instrument is set to count every 0.1 sec., the count will be halted after 10 sec. Press the black knob to the left of the PERIOD COUNTER, Lift the red clear plastic cover and set the counter to 100. Zero all the other counters on the instrument.

(b) Lift the PAUSE key on the Uher and run the tape to the beginning of the noise sample, press the PAUSE key to stop the tape.

(c) Push and turn clockwise the "SINGLE CHART / CONT RECORD" button on the level recorder and lower the pen. Lift the PAUSE key on the Uher to start the tape. Switch the "PULSE GENERATOR" Knob on the statistical analyzer to "On".

(d) As soon as the statistical distribution analyzer stops counting, press the PAUSE control on the Uher to stop the tape, release the "SINGLE CHART / CONT RECORD" button on the level recorder to stop the paper and lift the pen.

(e) Read the counts from the distribution analyzer and enter in the table on data sheet 2 (Figure II.4.A.& B.3).

(f) Set the PERIOD COUNTER on the distribution analyzer to 600. This will halt the count after 1 minute. Zero all the other counters on the instrument. Repeat items (c) and (d). Read the counts from the distribution analyzer and enter in the table on data sheet 3. (Figure II.4.A.& B.4)

(g) Set the PERIOD COUNTER on the distribution analyzer to 3000. This will halt the count after 5 minutes. Zero all the other counters on the instrument. Reread items (c) and (d). Read the counts from the distribution analyzer and enter in the table on data sheet 4. (Figure II.4.A.& B.5).

Calculation of Leq:

The calculation of an L_{eq} value from the statistical distribution analyzer data is described with reference to the example given in data sheet 1 of Figure II.4.A.& B.2.:

(a) Check that the sum of the individual counters is equal to the total count. If not, enter the correct sum rather than the total count opposite "SUM" on the data sheet.

Level Class	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Counter No	2	3	4	5	6	7	8	9	10	11
Class Time (%)	PARTIAL INDICES									
0.00	0	0	0	0	0	0	0	0	0	0
0.10	0	0	0	0	1	3	10	32	100	315
0.12	0	0	0	0	1	4	12	38	120	380
0.14	0	0	0	0	1	4	14	44	140	445
0.16	0	0	0	1	2	5	16	51	160	505
0.18	0	0	0	1	2	6	18	57	180	570
0.20	0	0	0	1	2	6	20	63	200	630
0.25	0	0	0	1	3	8	25	79	250	790
0.30	0	0	0	1	3	10	30	95	300	950
0.35	0	0	0	1	4	11	35	111	350	1110
0.40	0	0	0	1	4	13	40	127	400	1270
0.45	0	0	0	1	5	14	45	142	450	1420
0.50	0	0	1	2	5	16	50	158	500	1580
0.60	0	0	1	2	6	19	60	190	600	1900
0.70	0	0	1	2	7	22	70	222	700	2220
0.80	0	0	1	3	8	25	80	253	800	2530
0.90	0	0	1	3	9	29	90	285	900	2850
0.96 1.00	0	0	1	3	10	32	100	316	1000	3160
1.2	0	0	1	4	12	38	120	380	1200	3790
1.4	0	0	1	4	14	44	140	445	1400	4430
1.6	0	1	2	5	16	51	160	505	1600	5060
1.8	0	1	2	6	18	57	180	570	1800	5700
2.0	0	1	2	6	20	63	200	630	2000	6330
2.5	0	1	3	8	25	79	250	790	2500	7910
3.0	0	1	3	10	30	95	300	950	3000	9500
3.5	0	1	4	11	35	111	350	1110	3500	11 100
4.0	0	1	4	13	40	127	400	1270	4000	12 700
4.5	0	1	5	14	45	142	450	1420	4500	14 200
5.0	1	2	5	16	50	158	500	1580	5000	15 800
6.0	1	2	6	19	60	190	600	1900	6000	19 000
7.0	1	2	7	22	70	222	700	2220	7000	22 200
8.0	1	3	8	25	80	253	800	2530	8000	25 300
9.0	1	3	9	29	90	285	900	2850	9000	28 500
10.0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5060	16 000	50 600
18	2	6	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6330	20 000	63 300
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000

< 0	- 50	dB(A) + L dB(A)
1	12	Note Counter Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2	0	0	0
3	0	0	0
4	0	0	0
5	219	7.31	23
6	1426	47.53	475
7	1100	36.66	1161
8	226	7.54	754
9	29	0.96	304
10	0	0	0
11	0	0	0
SUM	3000	100	2717

$L_{eq} = L_o + \Delta L$

$L_o = 50.0$ dB(A)

$\Delta L = 26.8$ dB(A)

$L_{eq} = 76.8$ dB(A)

$\therefore L_{eq} = 77$ dBA for 5 minutes.

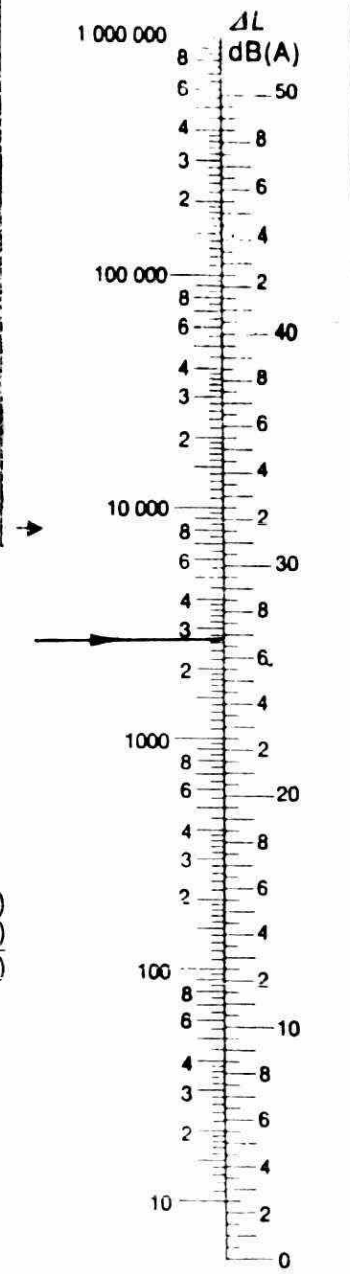


Figure II.4.A.& B.2

Trainee's Name:

Level Class	0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50
Counter No.	2	3	4	5	6	7	8	9	10	11
Class Time (%)	PARTIAL INDICES									
0 00	0	0	0	0	0	0	0	0	0	0
0 10	0	0	0	0	1	3	10	32	100	315
0 12	0	0	0	0	1	4	12	38	120	380
0 14	0	0	0	0	1	4	14	44	140	445
0 16	0	0	0	1	2	5	16	51	160	505
0 18	0	0	0	1	2	6	18	57	180	570
0 20	0	0	0	1	2	6	20	63	200	630
0 25	0	0	0	1	3	8	25	79	250	790
0 30	0	0	0	1	3	10	30	95	300	950
0 35	0	0	0	1	4	11	35	111	350	1110
0 40	0	0	0	1	4	13	40	127	400	1270
0 45	0	0	0	1	5	14	45	142	450	1420
0 50	0	0	1	2	5	16	50	158	500	1580
0 60	0	0	1	2	6	19	60	190	600	1900
0 70	0	0	1	2	7	22	70	222	700	2220
0 80	0	0	1	3	8	25	80	253	800	2530
0 90	0	0	1	3	9	29	90	285	900	2850
1 00	0	0	1	3	10	32	100	316	1000	3160
1 2	0	0	1	4	12	38	120	380	1200	3790
1 4	0	0	1	4	14	44	140	445	1400	4430
1 6	0	1	2	5	16	51	160	505	1600	5060
1 8	0	1	2	6	18	57	180	570	1800	5700
2 0	0	1	2	6	20	63	200	630	2000	6300
2 5	0	1	3	8	25	79	250	790	2500	7910
3 0	0	1	3	10	30	95	300	950	3000	9500
3 5	0	1	4	11	35	111	350	1110	3500	11 100
4 0	0	1	4	13	40	127	400	1270	4000	12 700
4 5	0	1	5	14	45	142	450	1420	4500	14 200
5 0	1	2	5	16	50	158	500	1580	5000	15 800
6 0	1	2	6	19	60	190	600	1900	6000	19 000
7 0	1	2	7	22	70	222	700	2220	7000	22 200
8 0	1	3	8	25	80	253	800	2530	8000	25 300
9 0	1	3	9	29	90	285	900	2850	9000	28 500
10 0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5060	16 000	50 600
18	2	6	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6300	20 000	63 000
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000

< 0	50	dB(A) + L dB(A)
1	12	Note Counter Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
SUM	100		

$L_{eq} = L_o + \Delta L$

$L_o =$ 50·0 dB(A)

$\Delta L =$ dB(A)

$L_{eq} =$ dB(A)

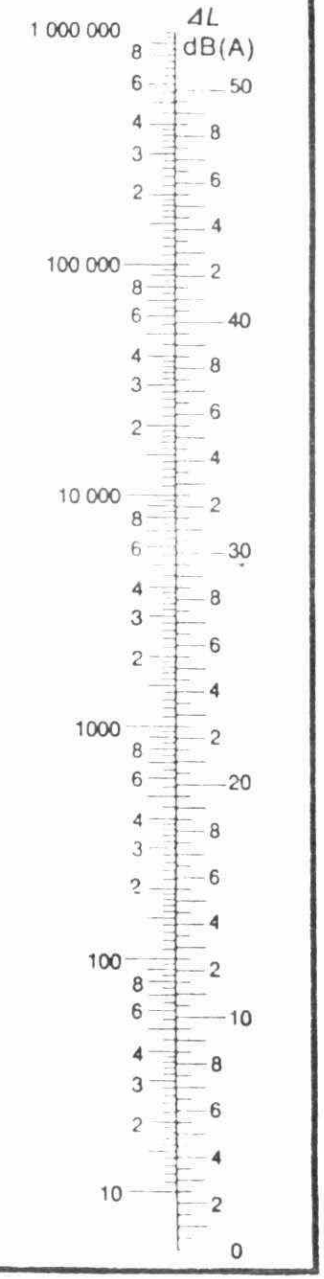


Figure II.4.A.& B.3

Trainee's Name:

Level Class	0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50
Counter No.	2	3	4	5	6	7	8	9	10	11
Class Time (%)	PARTIAL INDICES									
0 00	0	0	0	0	0	0	0	0	0	0
0 10	0	0	0	0	1	3	10	32	100	315
0 12	0	0	0	0	1	4	12	38	120	380
0 14	0	0	0	0	1	4	14	44	140	445
0 16	0	0	0	1	2	5	16	51	160	505
0 18	0	0	0	1	2	6	18	57	180	570
0 20	0	0	0	1	2	6	20	63	200	630
0 25	0	0	0	1	3	8	25	79	250	790
0 30	0	0	0	1	3	10	30	95	300	950
0 35	0	0	0	1	4	11	35	111	350	1110
0 40	0	0	0	1	4	13	40	127	400	1270
0 45	0	0	0	1	5	14	45	142	450	1420
0 50	0	0	1	2	5	16	50	158	500	1580
0 60	0	0	1	2	6	19	60	190	600	1900
0 70	0	0	1	2	7	22	70	222	700	2220
0 80	0	0	1	3	8	25	80	253	800	2530
0 90	0	0	1	3	9	29	90	285	900	2850
1 00	0	0	1	3	10	32	100	316	1000	3160
1 2	0	0	1	4	12	38	120	380	1200	3790
1 4	0	0	1	4	14	44	140	445	1400	4430
1 6	0	1	2	5	16	51	160	505	1600	5050
1 8	0	1	2	6	18	57	180	570	1800	5700
2 0	0	1	2	6	20	63	200	630	2000	6330
2 5	0	1	3	8	25	79	250	790	2500	7910
3 0	0	1	3	10	30	95	300	950	3000	9500
3 5	0	1	4	11	35	111	350	1110	3500	11 100
4 0	0	1	4	13	40	127	400	1270	4000	12 700
4 5	0	1	5	14	45	142	450	1420	4500	14 200
5 0	1	2	5	16	50	158	500	1580	5000	15 800
6 0	1	2	6	19	60	190	600	1900	6000	19 000
7 0	1	2	7	22	70	222	700	2220	7000	22 200
8 0	1	3	8	25	80	253	800	2530	8000	25 300
9 0	1	3	9	29	90	285	900	2850	9000	28 500
10 0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5050	16 000	50 500
18	2	6	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6330	20 000	63 300
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000

< 0	> 50	dB(A) - L dB(A)
1	12	Note Counter Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
SUM	600		

$L_{eq} = L_o + \Delta L$

$L_o =$ 50·0 dB(A)

$\Delta L =$ dB(A)

$L_{eq} =$ dB(A)

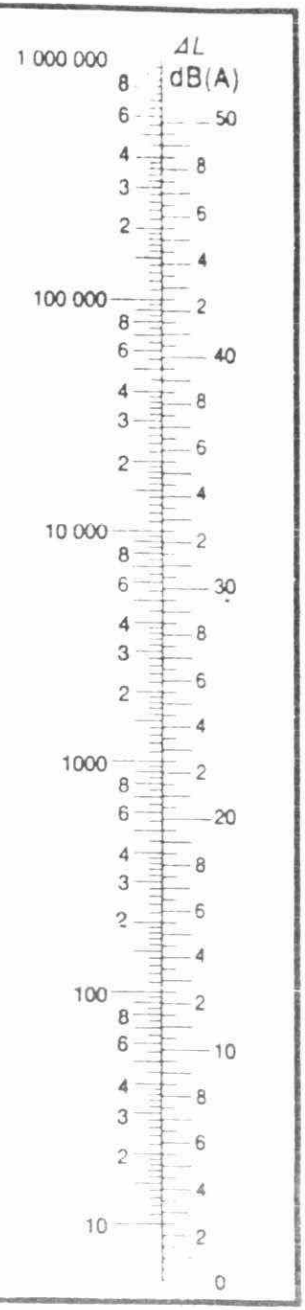


Figure II.4.A & B.4

Trainee's Name:

Level Class	0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50
Counter No.	2	3	4	5	6	7	8	9	10	11
Class Time (%)	PARTIAL INDICES									
0 00	0	0	0	0	0	0	0	0	0	0
0 10	0	0	0	0	1	3	10	32	100	315
0 12	0	0	0	0	1	4	12	38	120	380
0 14	0	0	0	0	1	4	14	44	140	445
0 16	0	0	0	1	2	5	16	51	160	505
0 18	0	0	0	1	2	6	18	57	180	570
0 20	0	0	0	1	2	6	20	63	200	630
0 25	0	0	0	1	3	8	25	79	250	790
0 30	0	0	0	1	3	10	30	95	300	950
0 35	0	0	0	1	4	11	35	111	350	1110
0 40	0	0	0	1	4	13	40	127	400	1270
0 45	0	0	0	1	5	14	45	142	450	1420
0 50	0	0	1	2	5	16	50	158	500	1580
0 60	0	0	1	2	6	19	60	190	600	1900
0 70	0	0	1	2	7	22	70	222	700	2220
0 80	0	0	1	3	8	25	80	253	800	2530
0 90	0	0	1	3	9	29	90	285	900	2850
1 00	0	0	1	3	10	32	100	316	1000	3160
1 2	0	0	1	4	12	38	120	380	1200	3790
1 4	0	0	1	4	14	44	140	445	1400	4430
1 6	0	1	2	5	16	51	160	505	1600	5050
1 8	0	1	2	6	18	57	180	570	1800	5700
2 0	0	1	2	6	20	63	200	630	2000	6330
2 5	0	1	3	8	25	79	250	790	2500	7910
3 0	0	1	3	10	30	95	300	950	3000	9500
3 5	0	1	4	11	35	111	350	1110	3500	11 100
4 0	0	1	4	13	40	127	400	1270	4000	12 700
4 5	0	1	5	14	45	142	450	1420	4500	14 200
5 0	1	2	5	16	50	158	500	1580	5000	15 800
6 0	1	2	6	19	60	190	600	1900	6000	19 000
7 0	1	2	7	22	70	222	700	2220	7000	22 200
8 0	1	3	8	25	80	253	800	2530	8000	25 300
9 0	1	3	9	29	90	285	900	2850	9000	28 500
10 0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5050	16 000	50 600
18	2	6	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6330	20 000	63 300
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000
SUM	100	320	1000	3160	10 000	31 600	100 000	316 000	1 000 000	3 160 000

< 0	50	dB(A) + L, dB(A)
1	12	Note Counter Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
SUM	3000		

$L_{eq} = L_o + \Delta L$

$L_o =$ 50·0 dB(A)

$\Delta L =$ dB(A)

$L_{eq} =$ dB(A)

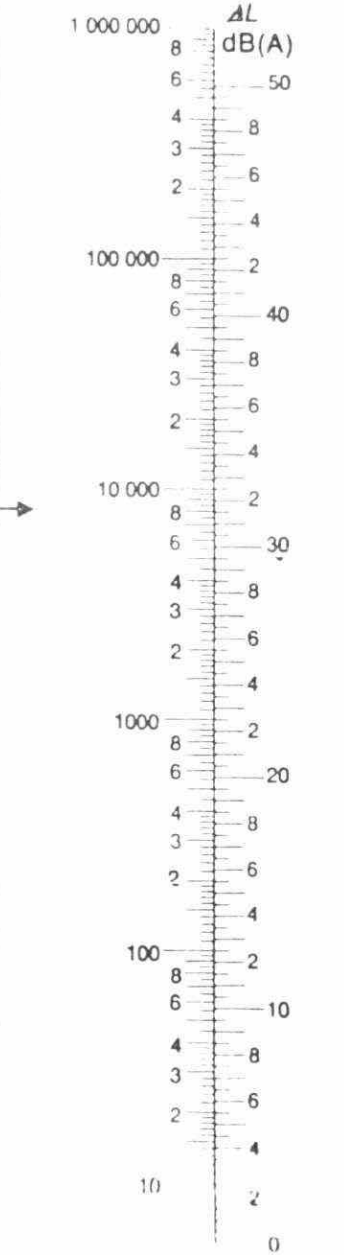


Figure II.4.A.& B.5

Level Class	0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50
Counter No.	2	3	4	5	6	7	8	9	10	11
Class Time (%)	PARTIAL INDICES									
0 00	0	0	0	0	0	0	0	0	0	0
0 10	0	0	0	0	1	3	10	32	100	315
0 12	0	0	0	0	1	4	12	38	120	380
0 14	0	0	0	0	1	4	14	44	140	445
0 16	0	0	0	1	2	5	16	51	160	505
0 18	0	0	0	1	2	6	18	57	180	570
0 20	0	0	0	1	2	6	20	63	200	630
0 25	0	0	0	1	3	8	25	79	250	790
0 30	0	0	0	1	3	10	30	95	300	950
0 35	0	0	0	1	4	11	35	111	350	1110
0 40	0	0	0	1	4	13	40	127	400	1270
0 45	0	0	0	1	5	14	45	142	450	1420
0 50	0	0	1	2	5	16	50	158	500	1580
0 60	0	0	1	2	6	19	60	190	600	1900
0 70	0	0	1	2	7	22	70	222	700	2220
0 80	0	0	1	3	8	25	80	253	800	2530
0 90	0	0	1	3	9	29	90	285	900	2850
1 00	0	0	1	3	10	32	100	316	1000	3160
1 2	0	0	1	4	12	38	120	380	1200	3790
1 4	0	0	1	4	14	44	140	445	1400	4430
1 6	0	1	2	5	16	51	160	505	1600	5060
1 8	0	1	2	6	18	57	180	570	1800	5700
2 0	0	1	2	6	20	63	200	630	2000	6330
2 5	0	1	3	8	25	79	250	790	2500	7910
3 0	0	1	3	10	30	95	300	950	3000	9500
3 5	0	1	4	11	35	111	350	1110	3500	11 100
4 0	0	1	4	13	40	127	400	1270	4000	12 700
4 5	0	1	5	14	45	142	450	1420	4500	14 200
5 0	1	2	5	16	50	158	500	1580	5000	15 800
6 0	1	2	6	19	60	190	600	1900	6000	19 000
7 0	1	2	7	22	70	222	700	2220	7000	22 200
8 0	1	3	8	25	80	253	800	2530	8000	25 300
9 0	1	3	9	29	90	285	900	2850	9000	28 500
10 0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5060	16 000	50 600
18	2	5	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6330	20 000	63 300
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000

0	50	dB(A) + L dB(A)
1	12	Note Counter Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
SUM			

$L_{eq} = L_o + \Delta L$

$L_o =$ 50·0 dB(A)

$\Delta L =$ dB(A)

$L_{eq} =$ dB(A)

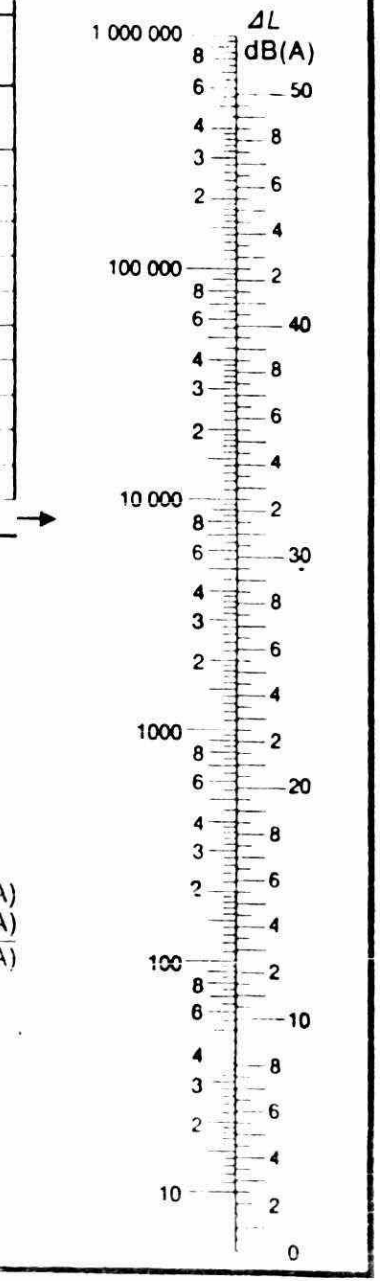


Figure II.4.A & B.6

(b) Divide the correct total reading by 30 and divide the result into each counter reading to obtain the class time % for each channel. Enter the results in the data sheet.

(c) Start with the highest channel with a non-zero count. In the example, this will be channel 9. Find the column corresponding to that channel in the large table to the left of the data sheet.

(d) Determine how to make up the class time % for that channel from the column of figures to the far left of the large table under Class Time % , in the example 0.8 plus 0.16 gives 0.96.

(e) For each of the previously determined figures go horizontally across the table to the relevant channel column and underline the number so found. See the example for Channel 9.

(f) Add together the numbers underlined in that column (giving 304 for the example) and enter this number in the Partial Index column of the table near the centre of the data sheet.

(g) Treat the remaining columns in a similar way, rounding class time % to the nearest 0.02% as necessary. Complete the Partial Index column in the table. Sum the Partial Indices, for the example, 2720 is obtained.

(h) Go to the scale to the far right of the data sheet and find the Total Partial Index. Look opposite this total to obtain $\triangle L$ in dBA. For the example, 26.8 dBA.

(i) Add on the baseline dBA value for the paper chart, in this case 50 dBA to give the value of L_{eq} For the example 50 + 26.8 = 76.8 dBA which rounds off to 77 dBA.

(j) Perform this calculation for all three sets of data and compare the results obtained. Discuss and explain any differences between the L_{eq} values.

NOTE: Please note that completed data sheets must be handed in at the end of this workshop period.

II.4.A.& B.3 L_{eq} ANALYSIS OF A TAPED SAMPLE OF INTERMITTENT NOISE

A tape recording is made of a machine which is in operation for a total of 1 3/4 hours during the hours of 07:00 and 19:00. The tape recording lasts for approximately five minutes, and is assumed to

be representative. It is required to calculate the L_{eq} for the daytime period of 12 hours using the time/level trade-off relationship for L_{eq}. Procedure to be followed:

(a) Calibrate the system as previously described using the calibration tone at the beginning of the new noise sample.

(b) Obtain the statistical distribution of the sample for a suitable duration as previously described. Read and enter the counter readings on data sheet 5 (Figure II.4.A.& B.6)/

(c) Complete the data sheet 6, hence calculating the 12 hour Leq due to the machine.

NOTE:
Please note that completed data sheets 5 and 6 must be handed in at the end of this workshop period.

II.4.A.&.B.4 DIFFERENTIATION BETWEEN L_{eq} RESULTS FOR CONTINUOUS AND INTERMITTENT NOISE:

In sub-section II.4.A.&.B.2 of this workshop,a continuous, but unsteady noise was analyzed for 10 seconds, 1 minute and 5 minutes. The 10 seconds L_{eq} was considerably different from the two others because a representative sample of the noise could not be taken in such a short time. The other two results were in close agreement, and the 5 minute result can be taken as fully representative of the noise. Having obtained a fully representative L_{eq} for the noise sample, it can be safely assumed that this L_{eq} value will apply for the whole time the machine is switched on or, in fact, for any length of time the machine was on.

In the case of the intermittent source this is not the case. First a representative L_{eq} was obtained for the noise sample, and this value taken to apply for the entire 1 3/4 hours for which the machine was switched on. The machine is off, however, for the rest of the day Assuming that the same L_{eq} level can be applied to the rest of the day would overestimate the noise due to the machine. Thus the measured L_{eq} level must be corrected from a 1 3/4 hour period to a 12 hour day time period using the time/level trade-off for L_{eq}. In this case it is very important to state the results for the machine as either X dBA L_{eq} for 1 3/4 hours or Y dBA L_{eq} for 12 hours.

II.4.A.& B.(Workshop) Name of Trainee:

Data Sheet 6

L_{eq} for 5 minutes =

$\therefore$ L_{eq} for 1 3/4 hours = (machine on all the time)

Trade-off relationship

$$L_{eq_2} = L_{eq_1} - 10 \log \frac{T_2}{T_1}$$

L_{eq_1} = dBA

T_1 = hours

T_2 = hours

$\therefore$ L_{eq_2} = - 10 log (——)

= - 10 log

= - 10

= -

$\therefore$ L_{eq_2} = dBA for hours.

Figure II.4.A.& B.7

OBJECTIVES:

Trainee will be able to:

1. Briefly describe the functioning of the human ear;
2. Give causes of hearing loss;
3. Indicate commonly accepted maximum safe exposure levels and times;
4. Outline the purpose of an audiogram and the frequencies which are of interest;
5. Name the instrument used to measure personal hearing and describe its principle of operation;
6. Describe a typical audiogram of a person with normal hearing;
7. Undergo a personal hearing test.

II.4.C.& D.1: FUNCTIONING OF THE HUMAN EAR:

This description will make the least possible use of medical terms. Please consult the Figure II.4.C.& D.1.

The outer ear is the part of the ear that is visible without surgery. It channels the sound to a diaphragm (the eardrum) which vibrates in response. The eardrum is no more than stretched skin. Water and foreign bodies are kept out of the middle and inner ears unless the eardrum is pierced or broken.

The middle ear is an area in which a system of levers, made of bone, transmit the motion of the eardrum to one end of a fluid-filled canal sending a pressure wave down the canal. To allow the eardrum to survive different static pressures exerted in the atmosphere outside the ear, the middle ear is connected by a vent to the nasal system. Swallowing opens the tube and allows the middle ear pressure to vent to the same pressure levels occurring outside the head.

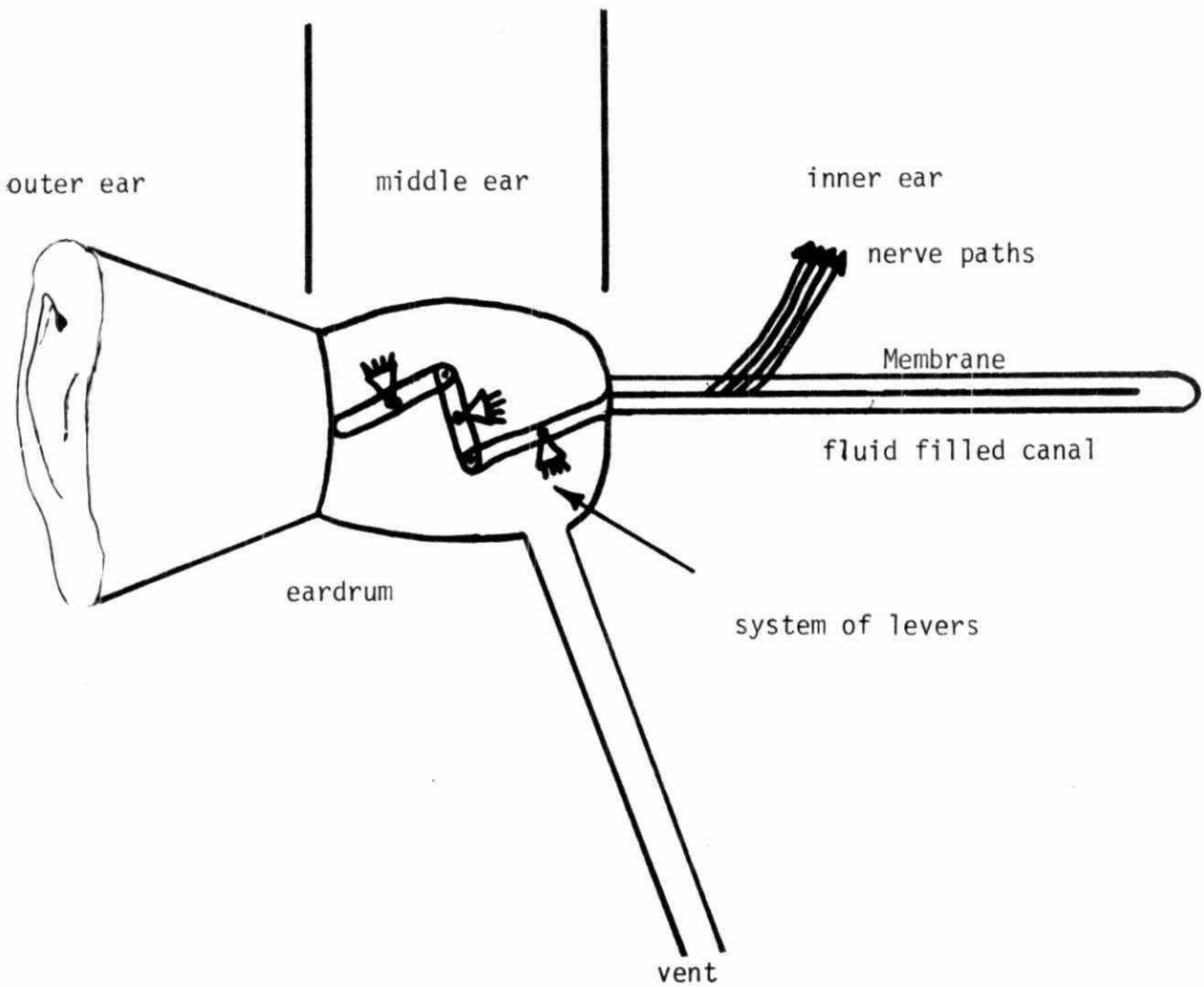


Figure II.4.C.& D.1: Schematic of Auditory System.

The inner ear consists of a fluid-filled canal, rolled up like a snail shell in nature (but here shown extended). The pressure wave in the fluid causes a membrane in the canal to move rather like a whip; certain frequencies cause certain parts of the membrane to move. Attached to the membrane are hair cells, which are tiny transducers (nerves) resembling hairs. When they move as the membrane causes them to, an electric current is transmitted to the brain. The brain translates the signal as sound.

Our ability to detect from where a sound emanates is thought to derive principally from the fact that a sound wave reaches our two ears at different instants depending where it comes from, and probably from the fact that the frequency response of the earlobe and its environs is different for different sound wave incidences.

II.4.C.& D.2. CAUSES OF HEARING LOSS:

1. The eardrum can be damaged by:
   - excessive pressure from sound, or another source like water pressure;
   - penetration by foreign objects such as are wrongly used to clean the ear.

   A hole in an eardrum does not always seriously impair hearing.

2. The middle ear can be damaged by:
   - growths on the bones of the lever system which prevent transmission of the eardrum's motion;
   - infections.

   Middle ear damage is often reversible by an operation if the problem is in the lever system, and by drugs if there is an infection.

3. The inner ear can be damaged by:
   - excess sound destroying the hair cells;
   - infections and cancers.

   Infections can sometimes be cured, but the other **problems are usually irreversible.**

II.4.C.& D.3. MAXIMUM SAFE NOISE EXPOSURE:

There are a number of different opinions about what amount of noise exposure is a safe maximum. Ontario law is rather similar to US law in this respect, and the Industrial Safety Act, 1971, covers the matter in Section III which is quoted here in full.

EXTRACT FROM THE INDUSTRIAL SAFETY ACT, 1971:

III.- (1) In this section "decibel" means decibel measured on a sound level meter conforming to standard S1.4-1971 of the American National Standards Institute operating on the A-weighting network with "slow" meter response.

(2) Where a person is exposed to a sound level of 90 decibels or greater:

(a) measures shall be taken to reduce the sound level below 90 decibels; and

(b) where such measures are not practicable;

(i) the duration of exposure set out in column 2 of the Table in subsection 5 shall not exceed the duration shown for the particular sound level set opposite thereto in column 1 of the Table in subsection 5, or

(ii) the person shall wear hearing protection.

(3) Where a person is exposed to a sound level of 115 decibels or greater, he shall wear hearing protection.

(4) Clearly-visible warning signs shall be posted at the approaches to an area where the sound level is more than 90 decibels.

(5) The warning signs referred to in subsection 4 shall state:

(a) the daily exposure for the particular sound level permitted by the following Table; and

(b) that hearing protection must be worn when the daily exposure is more than that permitted for the particular sound level.

Column 1	Column 2
Sound Level - in decibels	Duration - Hours per 24 hour day.
90	8
92	6
95	4
97	3
100	2
102	1½
105	1
110	½
115	¼ or less
Over 115	No exposure

Table 10: Allowable Safe Levels and Exposure Duration

(6) Where hearing protection is required by this section, the protection shall be sufficient to reduce the sound level below the sound level in column 1 of the Table in subsection 5 for the exposure corresponding to that sound level in column 2 of the Table in subsection 5. ..... Extract ends here.

It should be pointed out that this information from the Industrial Safety Act, 1971 is supplied here merely for interest.

II.4.C.& D.4. PURPOSE OF AN AUDIOGRAM:

It is desirable to measure a person's hearing acuity for several reasons:

1. It may **reveal**, where hearing loss is found, that noise exposure is excessive;
2. It may **confirm** over a period of time that their noise exposure is not ~~enormously~~ excessive;
3. It may **identify** the possibility of hearing problems due to other causes;
4. It may **identify** people with pre-existing hearing losses and suggest reduced noise exposures for the future;
5. It may **give a clue to social and work problems** due to a previously undetected hearing handicap;

No !!

The frequencies of most human speech range from about 250 to 5000 Hz. Since **the loss of speech communication** is more important than, say, an inability to enjoy high notes in music, **it is natural for hearing tests to cover the lower frequencies.** In addition, hearing loss due to noise generally manifests itself in a **loss in acuity around 4000-**6000 **Hz.** Thus, for general purposes, hearing tests cover a range from 250 to 4000 or 250 to 8000 Hz. For special purposes, higher frequencies may also be tested.

II.4.C.& D.5. PRINCIPLES OF AUDIOMETRY

Audiometry is the science of measuring the adequacy of a person's hearing. An audiometer is the instrument used in conjunction with headphones to achieve that.

The headphones are placed on the subject's head in an environment free from extraneous noise, usually a special booth. He is instructed to

press a button or in some other specified fashion indicate when he can just hear a noise through the headphones.

Each ear is tested separately. A pure tone of a given frequency is played into the ear and the sound pressure level at which the subject just hears it, is noted. This is repeated for tones of other frequencies, and is then performed for the other ear.

The "barely audible" sound pressure levels are compared with those for people with unimpaired hearing to arrive at "hearing loss" in decibels. Thus hearing loss at a given frequency is the difference between the sound pressure level just audible to the person being tested and that just audible to a person of unimpaired hearing.

II.4.C.& D.6 A TYPICAL AUDIOGRAM:

An audiogram is the graphical record of a person's hearing acuity, and a typical one is shown in the Figure II.4.C.& D.2.

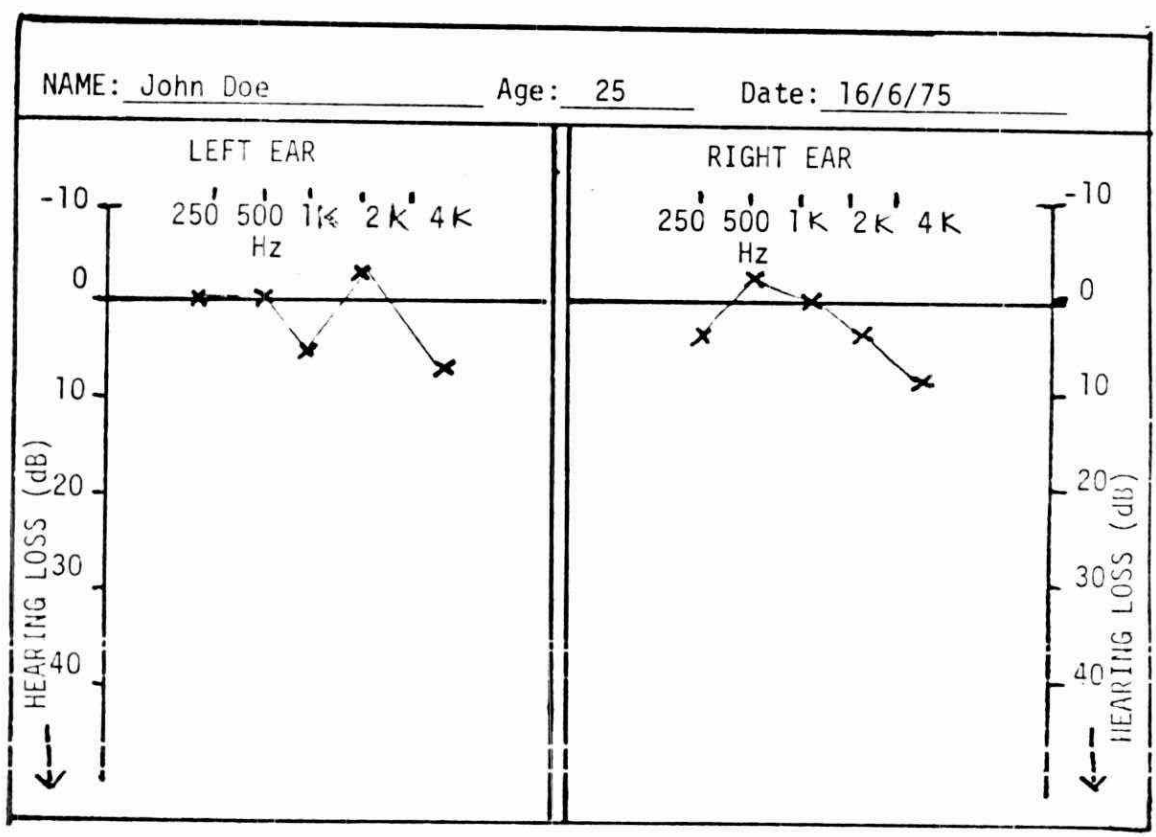


Figure II.4.C.& D. 2:A Typical Audiogram.

Here, the subject, Mr. John Doe is a young man with only the suggestion of a hearing loss in his right ear at 4000 Hz. Experimental variances will normally make us disregard a shift of 5dB or less.

Some points lie above the zero line, and while they could result from experimental error, it should be borne in mind that superior hearing is quite possible.

Persons with noise-induced hearing loss or **presbycusis (hearing-loss associated with age)** might produce an audiogram perhaps 15dB "Lower" at 2000 Hz and 25dB "lower" at 4000 Hz. These are the order of magnitudes involved in fairly severe losses.

Some audiograms are obtained from automatic audiometers which present each frequency tone many times, and require the subject to push a button for as long as he hears the tone. By decreasing the intensity of the tone when the subject presses the button, the subject soon releases the button, and the audiogram charts both the level at which the subject first perceives a tone increasing in level, and the level at which the subject last perceives a tone decreasing in level. These are not quite the same thing. Repeating this mode of stimulus presentation results in a more complete record of hearing acuity than usual.

People going for hearing testing should not have been exposed to high sound levels immediately prior to testing.

II.4.C.& D.7. PERSONAL HEARING TEST OF TRAINEES:

A personal hearing test of all trainees will be conducted during this workshop. The schedule for this test will be provided at the beginning of the course.

SUBJECT

ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.5.A.& B.(Review)

OBJECTIVES:

Trainee will be able to:

1. Clarify and improve upon his understanding of the course material covered during Environmental Acoustics Technology-II, to be accomplished through questions and answers during review session.

SUBJECT

ENVIRONMENTAL ACOUSTICS - II

TOPIC: II.5.C.& D.(Exam.)

OBJECTIVES:

Trainee will be able to:

1. Answer questions related to the acoustics theory, procedures, standards, instrumentation and measurement techniques covered during the course. Record sheets completed by trainee in the workshop periods will also be included as a part of the performance assessment.

Number	Log	Number	Log	Number	Log	Number	Log
1.0	0.00	4.0	0.60	7.0	0.85	1	0
						10	1
1.1	0.04	4.1	0.61	7.1	0.85	100	2
1.2	0.08	4.2	0.62	7.2	0.86	1000	3
1.3	0.11	4.3	0.63	7.3	0.86	10000	4
1.4	0.15	4.4	0.64	7.4	0.87	100000	5
1.5	0.18	4.5	0.65	7.5	0.88	1000000	6
1.6	0.20	4.6	0.66	7.6	0.88	etc.	
1.7	0.23	4.7	0.67	7.7	0.89		
1.8	0.26	4.8	0.68	7.8	0.89	10^0	0
1.9	0.28	4.9	0.69	7.9	0.90	10^1	1
						10^2	2
2.0	0.30	5.0	0.70	8.0	0.90	10^3	3
						10^4	4
2.1	0.32	5.1	0.71	8.1	0.91	10^5	5
2.2	0.34	5.2	0.72	8.2	0.91	10^6	6
2.3	0.36	5.3	0.72	8.3	0.92	etc.	
2.4	0.38	5.4	0.73	8.4	0.92		
2.5	0.40	5.5	0.74	8.5	0.93		
2.6	0.41	5.6	0.75	8.6	0.93		
2.7	0.43	5.7	0.76	8.7	0.94		
2.8	0.45	5.8	0.76	8.8	0.94		
2.9	0.46	5.9	0.77	8.9	0.95		
3.0	0.48	6.0	0.78	9.0	0.95		
3.1	0.49	6.1	0.79	9.1	0.96		
3.2	0.51	6.2	0.79	9.2	0.96		
3.3	0.52	6.3	0.80	9.3	0.97		
3.4	0.53	6.4	0.81	9.4	0.97		
3.5	0.54	6.5	0.81	9.5	0.98		
3.6	0.56	6.6	0.82	9.6	0.98		
3.7	0.57	6.7	0.83	9.7	0.99		
3.8	0.58	6.8	0.83	9.8	0.99		
3.9	0.59	6.9	0.84	9.9	1.00		

Log	Number	Log	Number	Log	Number	Log	Number
0.00	1.0	0.60	4.0	0.85	7.0	0	1
						1	10
0.04	1.1	0.61	4.1	0.85	7.1	2	100
0.08	1.2	0.62	4.2	0.86	7.2	3	1000
0.11	1.3	0.63	4.3	0.86	7.3	4	10000
0.15	1.4	0.64	4.4	0.87	7.4	5	100000
0.18	1.5	0.65	4.5	0.88	7.5	6	1000000
0.20	1.6	0.66	4.6	0.88	7.6		
0.23	1.7	0.67	4.7	0.89	7.7		
0.26	1.8	0.68	4.8	0.89	7.8	0	10^0
0.28	1.9	0.69	4.9	0.90	7.9	1	10^1
						2	10^2
0.30	2.0	0.70	5.0	0.90	8.0	3	10^3
						4	10^4
0.32	2.1	0.71	5.1	0.91	8.1	5	10^5
0.34	2.2	0.72	5.2	0.91	8.2	6	10^6
0.36	2.3	0.72	5.3	0.92	8.3		etc.
0.38	2.4	0.73	5.4	0.92	8.4		
0.40	2.5	0.74	5.5	0.93	8.5		
0.41	2.6	0.75	5.6	0.93	8.6		
0.43	2.7	0.76	5.7	0.94	8.7		
0.45	2.8	0.76	5.8	0.94	8.8		
0.46	2.9	0.77	5.9	0.95	8.9		
0.48	3.0	0.78	6.0	0.95	9.0		
0.49	3.1	0.79	6.1	0.96	9.1		
0.51	3.2	0.79	6.2	0.96	9.2		
0.52	3.3	0.80	6.3	0.97	9.3		
0.53	3.4	0.81	6.4	0.97	9.4		
0.54	3.5	0.81	6.5	0.98	9.5		
0.56	3.6	0.82	6.6	0.98	9.6		
0.57	3.7	0.83	6.7	0.99	9.7		
0.58	3.8	0.83	6.8	0.99	9.8		
0.59	3.9	0.84	6.9	1.00	9.9		

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